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Entomological Problems Imposed by War Conditions

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In view of the other papers which may be presented, discussion of the subject "Entomological Problems Imposed by War Conditions" will be limited to general rather than specific problems, except as the latter may be used as examples. Subsequent papers deal in a more detailed way with specific problems in the several fields and the primary purpose of this discourse is to set the stage for other discussions.

It has been thought by some that entomologists operating on a war basis should be concerning themselves primarily with problems that were nonexistent in peace times and that projects conducted during peace should now be abandoned in favor of new activities peculiar to war conditions and directly connected therewith. To a considerable extent this is true, but many of the problems that were important during peace times have become increasingly important in wartime. The idea that entrance of the United States into the war called for an immediate change in activities of all entomologists has resulted in a widespread feeling of discontent and restlessness by men who are continuing to work on problems which were important in peace times and have not been shifted or abandoned in favor of work directly connected with war activities. There is a universal desire among entomologists, as with other patriotic citizens, to place themselves where they can honestly feel that they, personally, are making the greatest possible contribution to the war effort.

Those who happen to be assigned to work directly related to the war effort, such as the control of insects affecting the health and comfort of military personnel, have the satisfaction of seeing in their efforts a direct contribution to the maintenance of the military machine. Others who are engaged in work bearing a sustaining relationship to the war, such as the control of insects affecting food crops, frequently fail to recognize their importance to a nation at war. They may be likened variously to reserve troops, waiting to be called in case of an emergency attack, to labor battalions called upon to build fortifications against a probable or expected attack, or to the ordnance experts working out, behind the lines, improved techniques and materials for combat use.

The entomologist engaged in protecting growing crops and in conserving these crops in storage from insect losses has an unusually important place in enabling the country to meet demands for adequate food supplies and materials for the fighting forces. Although in many cases the entomologist can serve his country most effectively by continuing in this field or in related fields and furnishing essential basic information which makes possible the protection of crops and their preservation from insects, he may consider such activities too commonplace to be satisfying. The following discussion will emphasize in some measure the importance of maintaining and intensifying entomological services on the home front.

Research designed to meet peacetime problems has contributed largely to the fund of information necessary for giving prompt, accurate answers needed to meet present demands. A review of L. O. Howard's article, "Entomology and the War," published in February 1919 in the *Scientific Monthly*, reveals that the problems then were very similar to those now confronting us, and shows to some degree the progress made by entomologists in meeting the demands placed upon them during the last war, in both civil and military fields. Although many of the basic problems are the same, there have been

modifications in modern warfare which invalidate methods used in the last war; moreover, wide differences in the geographical areas covered and in the climates encountered present new questions. The very fact that the field of operations is now almost world-wide greatly increases the number and variety of problems for which entomologists are called on to find quick and workable solutions.

The protection of military personnel from the attack of disease-carrying and pestiferous insects is a problem of prime importance. The rapid movement of modern warfare has invalidated certain of the standard practices for the control of insects transmitting those powerful enemies of armies—typhus, yellow fever, and malaria. The control of body lice, the transmitters of typhus fever, was accomplished in the last war in part by steam sterilization of clothing. This was possible where a base of operations could be maintained close to the fighting front and steam-sterilizing equipment could be set up and made available. This method has a number of disadvantages. The equipment is not sufficiently mobile for present conditions and requires critical materials in its manufacture. Steam treatment has an adverse effect on some materials and requires a longer period than is available for the most convenient usage. Fumigation methods have been developed which do not have these handicaps. With troops likely to move into louse-infested areas and those areas in which typhus fever is endemic, there is urgent need for the development of effective methods of louse control that can be used by the individual soldier or by small groups under combat conditions. This need is being effectively met, although no specific information on the results of the experimental work being conducted toward this end may be given now.

Around relatively permanent camps it is possible, through the ordinary methods of drainage and treatment of breeding places, to protect troops from mosquitoes carrying malaria and yellow fever. Under many of the conditions facing our troops at this time such methods are totally impracticable. Protection from both the disease-bearing and the pestiferous mosquitoes must be achieved, in frequent instances, through the use of repellents that can be applied by individual soldiers, and through direct control with sprays or aerosols applied in tents and barracks to prevent biting by nocturnal species while the soldiers sleep. Research results are being applied as rapidly as justified, and the great progress made in this field has been of material benefit to present military operations. Civilian populations will also be greatly benefited after the war.

Effective repellents and insecticides are also needed for use against the numerous other pestiferous species of arthropods—ticks, chiggers, sand flies, stableflies, eye gnats, fleas, and others—encountered in field maneuvers. Although some rather extensive work is in progress in this field as applied to American species, much remains to be done, and many of the species that will be encountered in the far-flung corners of the globe in which our soldiers are operating require additional study.

Methods for the control of bedbugs, cockroaches, and houseflies are already known but there is still a need to make this information available and to adapt the methods to new conditions. Insects have the habit of presenting new aspects under special conditions and their control may then require entirely new methods. The common stablefly, or "dog fly," for example, threatened to assume the role of a major military handicap to the training of forces along the western Florida coast until control methods were developed and applied. These methods require treatment, with a mixture of creosote and sea water, of miles of windrows of seaweed thrown up along the beaches. When not treated this seaweed produces hordes of aggressive, biting flies. Undoubtedly comparable instances will arise with other insects for which normally satisfactory procedures will not be effective.

In the warfare practiced today nearly everything that affects the economic well-being, the health, or the agricultural productivity of the nation is intimately associated with its effectiveness as a fighting unit. Those activities which relate to food production may be considered only second in importance to those affecting actual military operations. Armies cannot fight without food any more than they can fight without munitions or equipment. After crops are planted there are three major hazards—weather, insects, and diseases—which, in spite of the farmers'

best efforts, may adversely affect the size of the harvest. The first of these, weather, cannot be controlled. The other two are usually subject to some type of control or amelioration of effect. Proper attention to these may make the difference between successfully reaching the production demands and failing to produce adequate supplies of food, fibers, and other materials.

During the last war there was a food-production drive similar to that occurring now, but it was less selective than today's campaign, which calls for the production of certain amounts of specified crops based on the estimated present and future needs for these crops in a war economy. The Secretary of Agriculture has established production goals for a long list of agricultural crops and has estimated the acreage necessary to reach these objectives. These goals are admittedly high on certain of the most essential crops because the need is great, and because the production of abundant crops is an instrument of peace as well as war. Farmers must strain their resources to the utmost to meet the production goals and supply food to our armies, our Allies, and ourselves. This must be done in the face of restricted supplies of farm machinery, labor, and certain agricultural chemicals, including insecticides. We can no longer compensate for insect loss by planting an extra acre to feed insects. Every productive acre is important in meeting the goals. Small losses, traditionally tolerated, must now be eliminated wherever possible and all large-scale losses from preventable insect attack must be avoided, even at much higher cost than would normally be considered economical. The very restrictions on the supply of labor and machinery, which make extra planting to feed insects impracticable, place severe handicaps on insect-control efforts. The insecticides must be carefully used to avoid wastage. Certain of these will not be so abundant as they ordinarily are and others will be so restricted that they can be employed only on crops of the highest priority. Methods of controlling insects by cultural and other means not involving the use of insecticides must be practiced to the fullest extent. To obtain economical, practical insect control under these handicaps is no mean task. It challenges the resourcefulness, ingenuity, and fortitude of entomologists.

The shortages which now exist or are impending present us with this immediate problem, how can we devise measures that will give the maximum of control with the minimum amount of material and of farm labor. They also impose on entomologists the responsibility for planning their research in such a way that they may be in a position to meet reductions in supplies of insecticides that now appear to be available in abundance, so that farmers will not be caught short in case of unexpected insect outbreaks or sudden changes in the war situation or in shipping facilities that might affect insecticide availability. Adjustments to the insecticide-supply situation involve the intelligent recommendation of substitutes for war-limited materials and a stepped-up program of research on substitutes for some of the more critical ones. They also involve a careful review of previous experimental work in which various insecticides, now more abundant than others, have been used but have been subsequently abandoned because of the somewhat increased kill by the materials now recommended. There is the possibility of rather distinctly reducing the dosage per acre, or decreasing the concentration of the active ingredient in the sprays or dusts, or improving the schedules for application of materials so as to eliminate extra applications that may not be absolutely needed. This is no time for pet formulas nor is it a time for the utilization of untested materials—except in great emergencies—because if these formulas or materials fail to be effective, not only may critical insecticides be wasted but also the crops to which the insecticides have been applied may be lost. In spite of this statement, it will many times be necessary to make recommendations on the basis of information that we would ordinarily not consider entirely adequate. There must be a flexibility in control recommendations, and in the mental processes of entomologists, which will enable a rapid adaptation of recommendations to changing conditions. The research program should be one step in advance of possible shifts so that it will be feasible to adjust procedures rapidly if and when the occasion demands.

Some of the newer insecticides that are made from noncritical materials may be utilized to distinct advantage. The de-

velopment of entirely new materials and the establishment of their usefulness in specific fields take so long that it is unlikely they can be developed in time to alleviate shortages during the period of the war—if we can share even a small part of the optimism now expressed in some quarters about its duration. Furthermore, there may be serious difficulties in making factory changes to provide for quantity production of new materials. Certain materials, however, on which a considerable amount of developmental work has already been done may be used as insecticides in special cases to considerable advantage although hitherto they have not been recommended for such use.

Entirely aside from the problem of recommendations and the development of insecticidal means of insect control with existing materials, there is a serious distributional problem with regard to insecticides which must be a matter of direct concern to entomologists. They must contribute as far as they can to information which will make possible an intelligent distribution of insecticides, available in limited quantities, to places where they are needed. Estimation of the amount of insecticides required for given crops or determination of the places where they must be used is not so simple a matter as is, for example, the problem of establishing fertilizer requirements. The quantity of fertilizer needed to produce a crop can be estimated rather readily for a given acreage of a given crop in a given locality and varies little from one season to another. This, as you all know, is not true in estimating insecticide requirements. Excessively large quantities of insecticides may be needed to suppress an insect outbreak in a given locality in one season and the following year none may be needed. This fluctuation in demand may affect critically not only those insecticidal materials that are available in fairly large amounts but also those of which the supplies are somewhat restricted. Ordinarily the trade has been able to build up inventories that carry over from one season to another so that it is in a position rapidly to meet emergency needs for insecticidal materials. During the last two years, however, inventories have been severely reduced. It will be necessary to get the most equitable distribution of insecticides possible, considering the occurrence of the insects against which these insecticides are needed and the importance of the crops which are infested. An example of what can be accomplished in this regard is the work carried out last year on the boll weevil through the cooperation of the various State entomological agencies and the Bureau of Entomology and Plant Quarantine. Weekly and, in some instances, daily reports were received on the development of the boll weevil, cotton leafworm, and bollworm in the cotton-producing South. This information was relayed immediately through the appropriate Departmental agencies to manufacturers and distributors of insecticides, and a considerable proportion of the insecticide distribution during the latter part of the season, when shortages in certain localities were becoming somewhat apparent, was made on the basis of these reports. An increase in the amount of arsenic allocated for the manufacture of insecticides was also made on the basis of facts thus developed.

A sudden epidemic of the pea aphid over a few of the north central states might completely upset the rotenone balance, which even now is on the deficit side of the ledger. We should not be caught napping and permit serious losses to occur because of lack of information on the development of such epidemics. As you know, funds for the support of the Insect Pest Survey of the Bureau of Entomology and Plant Quarantine have been so reduced that that office is unable to keep up the voluntary reporting system that has been of such value hitherto. Even at the levels at which it has operated in the past, it could not meet a demand such as that referred to here. Widespread cooperative activity, to which the Bureau of Entomology and Plant Quarantine will lend all the assistance possible, is necessary to keep up-to-date information flowing into the agencies responsible for the allocation and distribution of insecticides and insecticidal materials, if serious dislocations of insecticide supplies and heavy crop losses are to be avoided. The Bureau is being called on by these agencies repeatedly and consistently. You will help it, and yourselves, by supplying current information on insect developments so that responsible agencies may take intelligent action.

The limitations of insecticides, of man

power, and of equipment raise the question whether there are things we might do in the field of preventive entomology to conserve these resources. The whole problem places unusual emphasis on preventing the development of large outbreaks which would entail the use of quantities of insecticides and man power needed for other normal usages and to prevent the loss of crops which are always sacrificed to insects where these occur in outbreak numbers. Some insects, such as certain species of grasshoppers and the Mormon cricket, can be attacked in concentration centers or hold-over areas before heavy population build-up occurs. Large-scale outbreaks in adjacent areas may be prevented sometimes at relatively small expenditure of man power and equipment. F. T. Cowan, of the Bureau of Entomology and Plant Quarantine, has recently made an evaluation of the outbreak of the Mormon cricket which started as small bands in 1934 in the Pryor Mountains in south-central Montana. These crickets could have been destroyed at that time at an estimated cost of $26,000. During 1935 and 1936 the bands increased greatly in size, moved out of the mountains, and by the spring of 1937 were attacking crops in the Yellowstone Valley. During the period from 1937 to 1941, $500,000 was spent by county, state, and federal agencies in fighting excessive migrations from the Pryor Mountains, and during the same period crop damage amounted to at least $500,000, practically all of which could have been saved by the expenditure of $26,000 worth of man power and materials in 1934. We have, on the other hand, a number of instances where early attention to relatively small bands of Mormon crickets has resulted in a complete prevention of crop loss even when surrounding untreated areas were becoming increasingly infested. Swarms of grasshoppers, originating in idle and depleted range in north-central South Dakota and south-central North Dakota in 1938, swept across western North Dakota and into the eastern third of Montana the same year. In that year a loss of $6,000,000 was inflicted on crops in Montana alone. During the next 2 years progeny of these grasshoppers continued across Montana to the Rocky Mountains and northward into Manitoba, Saskatchewan, and Alberta. During 3 years the value of crops destroyed by these migrating swarms and the actual cost of protecting crops that were saved amounted to more than $30,000,000. The original infestation in North and South Dakota in the spring of 1938 could have been controlled and subsequent extensive migrations and losses prevented by the expenditure of $250,000.

We cannot afford such occurrences even in times of peace. And it is incredible that they should be permitted in times of war, when we are under such pressure for the production of food, feeds, and fibers. There is such a direct interest in food production as an instrument of both war and peace that the Federal Government would be justified in going much further in attempting to prevent such occurrences as this than it might be justified in doing under other circumstances. It is certainly the responsibility of all entomologists to cooperate in preventing, as far as possible, occurrences similar to those mentioned, even though they may be on a much smaller scale. We cannot afford to have outbreaks of armyworms, chinch bugs, cotton leafworm, and similar insects creep up on us unawares. Nor, when these outbreaks do occur, can we afford to neglect the appropriate measures to prevent losses of critical food supplies and materials.

The United States programs for production of foods and materials have posed a number of new problems that are associated with crops not ordinarily grown, or with crops grown in areas to which they are strangers. We must produce large quantities of vegetable seeds if our program of truck-crop production is to be maintained. We are dependent on our own supplies of sugar-beet seed. Large crops of vetch and Austrian pea seeds are needed for planting to replace commercial nitrogen fertilizers not now available. Many of these seed crops are subject to severe insect losses; in fact, sometimes these losses are such that the seeds cannot be economically or effectively produced without adequate insect control.

New crops strange to the United States, such as hemp, guayule, and kok-saghyz, are being produced either on a commercial scale or on a large experimental basis. We know little as yet about the insect problems that will arise with these new crops in the various areas within the United States in which they are being

planted. Yet these crops are of such vital importance at this time that insect depredations upon them must be prevented.

In addition to the insects attacking these crops, there is the problem of obtaining adequate pollination of a number of them and of other seed and fruit crops which must be produced to meet our present agricultural needs. A recent review of the literature by the Division of Bee Culture of the Bureau of Entomology and Plant Quarantine indicates that wild pollinating insects are not sufficient in number adequately to pollinate our agricultural crops, and that at least 50 agricultural crops, including a long list of fruits, legumes, crop seeds, and field crops, depend on honeybees for pollination or yield more abundantly when these bees are plentiful. Although honey and beeswax are in demand, war conditions are affecting bee production through priority allocations of materials and through shortage in man power, this shortage being peculiarly acute because of the highly specialized nature of the industry. Under these conditions apiculture is likely to decrease rather than increase under war conditions unless special stimulus is given it. Honeybees as pollinators have been relegated in the minds of many agriculturists to a relatively unimportant position. Bees have been valued more for their production of honey and beeswax than for the pollination of agricultural crops, which, nevertheless, is their most important function in the broad agricultural picture. The maintenance of sufficient honeybees to secure adequate pollination deserves the interested and active attention not only of entomologists but of agronomists and agriculturists generally.

Demands for leather, particularly of the higher grades, have increased tremendously as a result of war activities. The need for the control of cattle grubs, which not only affect the quality of leather produced but the productivity of livestock, has been recognized in the recent cooperative campaign conducted by the various States, the Extension Service, and the Bureau of Entomology and Plant Quarantine. This effort should be continued and expanded if maximum effectiveness is to be obtained.

Even in normal times huge losses occur as a result of insect infestation after many foods and agricultural materials have been produced. Except in a few instances, such as in the storage of the large quantities of wheat and corn now being held in farmers' bins, country elevators, and terminal elevators throughout the land, there has been relatively little pressure for protection of stored foodstuffs and materials from the attack of insect pests as compared with protection from the insects that cut down food production. As time goes on and large stocks, which are being built up and stored, have had an opportunity to become infested, the need for protection from storage pests will become increasingly acute. Entomologists have already received calls from various agencies for advice on methods of protecting various materials and commodities in storage, including raw wool, woolen clothing and furs, tobacco, dried beans and peas, livestock feeds, dehydrated products, dried fruit, and others. In addition, advice and information have been requested on the control of numerous insect depredators on military and civilian materials. These inquiries include a wide range of problems, such as the protection of valuable spruce lumber from damage by ambrosia beetles, the protection from insect attack of truck bodies and wheelbarrows in the tropics, methods of protecting stored hickory and ash to be used in tool handles and gun stocks, and methods of preventing damage from termites to wooden structures built in connection with the war program.

Experience in the last war indicates that the problems involved in insect losses from storage pests is only beginning—that they may be expected to increase as supply bases are established in tropical areas, particularly if a considerable inventory of supplies is maintained under these conditions. When supplies have exceeded sufficiently the immediate demand to provide large reserve stocks in storage both here and abroad, problems of protection from insect attack will become increasingly important and entomological information and advice will be needed to prevent serious losses.

The need for steel in our modern mechanized warfare is such that it has been necessary to substitute wood in many cases where steel was previously used. This substitution has been made for structural supports in buildings, for culverts in road making, for highway bridges, and even for gasoline tanks. Under many of the condi-

tions of its use wood is subject to attack by termites and other wood-destroying insects, particularly under tropical and semitropical conditions. Consideration must be given to the species of wood used, its susceptibility to attack by insects and to decay, and methods of treating wood so used to prevent its early deterioration.

The storage of the vast quantities of food materials that are being produced for civilian supply presents important problems in the case of those crops already being produced in excess of immediate demands in the United States, particularly the cereal crops, which are so subject to insect infestation. The solution of these problems of protection of materials in storage is complicated to some extent, as is the control of insects on growing crops, by the restrictions on the availability of chemicals because of war needs.

Critical problems in plant-quarantine administration and enforcement accompany war activities, since the resulting important changes in transportation necessitate numerous adjustments in procedures and practices aimed to safeguard the importation and movement of materials that may carry dangerous insect pests or plant diseases. The need for speed in the movement of military and civilian supplies has made it necessary to expedite all operations. Furthermore, the need for secrecy in safeguarding information regarding transportation and the movement of commodities to and from other countries has made it necessary to discontinue standard reports on imports and exports. Plant-quarantine inspectors at the ports have more direct responsibility than in normal times for actions taken to prevent the entry of dangerous pests, because decisions must be made rapidly on the basis of existing conditions, which are rapidly changing.

The upsetting of normal channels of trade as a result of our own military activity and that of the enemy has created important problems in the movement of certain important commodities that are under quarantine regulation. It has been necessary, for example, to arrange for entry at some southern ports of shipments of cotton needed in war activities, and to ship this material overland under bond to designated fumigation plants for treatment. Surface fumigation methods have been devised and used as a temporary safeguard. Other restrictions governing the importation of cotton and cotton linters have required modification to permit more rapid importation for utilization of fibers needed in the preparation of strategic materials. Similar changes in requirements, which would not be acceptable under normal conditions, have been made for fruits and vegetables.

The convoy system, involving the arrival simultaneously of large numbers of ships, has necessitated changes in assignments and inspection practices to offset, as far as possible, the additional risk of introduction of injurious insect pests and plant diseases with such arrivals. This increased risk results from the extremely heavy inspection load placed on port inspectors and the great urgency that there be no delay in clearing the ships. Moreover, speed of movement has become so much greater with the advent of the long-range planes that the likelihood of insect or plant disease invaders reaching the United States from foreign shores in viable condition has been greatly increased.

Experience during past wars has indicated that wartime is a particularly hazardous period as far as the introduction of new pests and plant diseases is concerned. The extensive movements of men, materials, and equipment from one nation to another under emergency conditions intensifies the possibility of accidental introduction of foreign insects, to say nothing of the possibility of purposeful introduction of crop pests by enemies of the United States.

Although the movement of supplies and materials under war conditions has made necessary the relaxation of some of the safeguards ordinarily considered essential in protection from pest introduction, the problem of giving the maximum protection possible consistent with keeping the channels of commerce open under war conditions is one that confronts quarantine officers. Certain risks must be accepted as a part of the hazards of war, but every effort must be made to minimize these risks and to accept only those which are imperative and cannot be avoided by modifications of methods and procedures.

State and Federal regulatory officials have an important problem before them in the prevention of spread of pests within our borders, as well as for the early detec-

tion of new pests which might affect food production, either during the war or after the war is over. However, the great urgency involved in the movement of war supplies and of the food to sustain our armed forces complicates matters and makes even more necessary than under normal conditions the elimination of all quarantine regulations that might interfere with the free movement of produce and that are not absolutely required to prevent the spread of harmful pests. The development of methods of treatment that will eliminate pest risk yet permit free movement of produce challenges the ingenuity of research workers and quarantine officials alike.

Insects are so cosmopolitan, so egregious, and so varied in habits and tastes that they create important problems in widely separated fields, sometimes where they are least expected. So many of these problems are peculiar to or aggravated by war conditions that no attempt has been made to catalogue them or classify them in any detail in this brief discussion. A few of the more important ones, however, have been mentioned in their relation to war activities. One must be impressed, after even so limited a review as this, with the important place held by the entomologist in winning the war, and must realize how essential it is that every entomologist recognize his part and that he do it well.—1-9-43.

Further Studies on Rotenone and Other Organic Insecticides for Codling Moth Control[1,2]

S. W. HARMAN, *New York State Agricultural Experiment Station, Geneva, N. Y.*

One of the most serious problems in connection with codling moth control in the past has been that of removing the objectionable spray residues adhering to the fruit following the application of some of our most effective spray schedules. In an attempt to avoid this troublesome and expensive operation, the introduction of certain organic insecticides, such as nicotine, into the codling moth control program has proved of the greatest assistance to the apple grower, particularly in heavily infested districts.

Other organic insecticides such as rotenone and pyrethrum, although increasing tremendously in importance in certain other fields of insect control, have for some reason never found any real place in the codling moth program. Most of the early work with rotenone and pyrethrum as applied to the codling moth problem had to do very largely with commercial extracts and whether reported by the practical grower or the research worker, the results have in general been disappointing wherever such extracts have been employed.

Our own early work with such materials was far from encouraging, but during the past 3 or 4 years where, instead of extracts, we have employed the finely powdered plant product direct, the results have been much more promising as pointed out in an earlier report (Harman 1942).

Since a continuation of these studies during the past season tend to confirm the 1941 findings and provide additional information bearing on the possible use of these materials for combating the codling moth, it has seemed advisable to make these recent findings available to other workers. This paper presents the results of field tests with organic insecticides used in codling moth control studies during 1942.

The experiments were designed to measure the relative value of a number of organic insecticides applied to control the codling moth. Lead arsenate treatments were used for comparison. Two McIntosh orchards approximately one mile apart were selected for the tests, many of the treatments being run in parallel in the two plantings. Both orchards were heavily infested and a considerable number of untreated trees were left in each planting to insure an abundant moth population throughout the season.

A total of eight cover sprays were applied with a standard orchard sprayer maintaining 400 pounds pressure at the

[1] Eastern Branch Program, New York, November, 1942.
[2] Journal Paper No. 545, New York State Agricultural Experiment Station, Geneva, N. Y., February 9, 1943.

pump. Applications were made with a *Friend* pecan gun using a disc with an eight-inch aperture. Four applications were made for each of the two broods of worms between June 11 and August 27. When applying the cover sprays a special effort was made to insure a smooth uniform deposit that would leave the fruit practically free of visible residue at harvest time.

The list of materials used in the tests included the following:

Black Leaf 155, manufactured by the Tobacco By-Products and Chemical Corporation, contained 14 per cent free nicotine fixed in bentonite. This material was used with each of three spreaders, namely, 5 ounces of *Grasselli Spreader-Sticker (SS3)*, 4 ounces of *Rohm & Haas B-1956*, or 2 ounces of blood albumen. The *Black Leaf 155* performed well with any of the above spreaders. The blood albumen, which was used in the undiluted form, proved the least desirable largely on account of the foaming and consequent loss of pressure that frequently accompanied its use with nicotine as well as with rotenone bearing powders.

The *Lethane 60-rotenone concentrate* which was supplied by the Rohm & Haas Company consisted of 20 per cent by weight of *Lethane 60* and 80 per cent of powdered derris or cube root standardized at 5 per cent rotenone. The spreader, *B-1956*, also a Rohm & Haas product, was used at a rate of 4 ounces in 100 gallons.

Ground derris root contained 5.7 per cent rotenone. Four ounces of B-1956, 1 pint of *Nu-Film*, a product of the Miller Chemical and Fertilizer Corporation, 5 ounces of *Grasselli Spreader-Sticker*, or 2 ounces of blood albumen were employed as spreaders where rotenone sprays were used.

Pyrethrum was used in the form of finely ground Kenya pyrethrum flowers, assaying about 1.3 per cent pyrethrins. Two ounces of blood albumen proved a very satisfactory spreader for the pyrethrum.

Pyrocide 20, a pyrethrum extract containing 2.5 per cent pyrethrins, was supplied by the McLaughlin Gormley King Company. As a spreader, 2 ounces of blood albumen worked nicely with the *Pyrocide* spray.

Standard acid lead arsenate was used with an equal amount of hydrated lime as a safener and with a half-pound of soybean flour (*Spraysoy A*) as the spreading agent.

The *summer oils* used in combination with the insecticides were Socony Vacuum oils *875 R. F.* (*Prorex Oil C*) and *P. D. 481A*. These oils were both manufactured from mid-continent crude and differed principally in their degree of refinement. The viscosity of both oils ranged between 60 and 65 seconds Saybolt, while the unsulfonated residue of oil *875 R. F.* was 92 per cent and *P. D. 481A* approximately 80 per cent. In addition, the last mentioned oil was compounded with an oxidation inhibitor for the purpose of minimizing spray injury that might follow the use of an oil of such low unsulfonated residue.

The dropped fruit from all the plats was collected and injuries recorded a number of times during the summer to furnish complete data on codling moth damage. The crop was harvested in September and records made at that time of the number of stings and deep worm holes that were found on the fruit. The figures in tables 1 and 2 represent the average of the total number of stings and deep injuries found on the total crop of fruit and expressed as percentages.

DISCUSSION.—*Nicotine.* Experiments carried out during the past few years have shown that 1 or 2 quarts of a summer spray oil incorporated in 100 gallons of most sprays add materially to the insecticidal value of the mixture. For this reason oil was used with the organic materials whenever possible.

In table 1 several different nicotine sprays are listed. The only noticeable variation in insect control occurred when the tests included different types of oil or a different variety of apple.

Nicotine, either in the form of the sulfate (*Black Leaf 40*) or fixed nicotine (*Black Leaf 155*) when combined with oil *875 R. F.* gave somewhat better results than nicotine with oil *P. D. 481A*. This performance was in line with the results of earlier tests made to compare the ovicidal value of the two oils. The differences, altho not great, are indicated when a comparison is made of the control data for Plats 1 and 2, and 4 and 6 in table 1.

Plats 2 and 3 (Table 1) received identical treatment except that different varieties of apples were used. Invariably the

Table 1.—Codling moth control on apples with organic insecticides, 1942.

Plat[3]	Materials Used[1] Amounts in 100 Gallons	Stings	Deep Worm Holes	Total Injury
1	*Black Leaf 40* 0.75 pt.; *Oil 481* 3 pts.; blood 2 oz.	6.3%	6.6%	12.9%
2	*Black Leaf 40* 0.75 pt.; *Oil 875* 3 pts.; blood 2 oz.	7.7	2.3	10.0
3	*Black Leaf 40* 0.75 pt.; *Oil 875* 3 pts.; blood 2 oz.	24.4	7.5	31.9
4	*Black Leaf 155* 1.5 lbs.; *Oil 875* 3 pts.; blood 2 oz.	4.5	3.3	7.8
5	*Black Leaf 155* 1.5 lbs.; *Oil 875* 3 pts.; blood 2 oz.	10.9	6.5	17.4
6	*Black Leaf 155* 1.5 lbs.; *Oil 481* 3 pts.; blood 2 oz.	7.0	6.1	13.1
7	*Black Leaf 155* 3 lbs.; *Oil 875* 1 qt.; *B1956* 4 oz.	3.8	1.5	5.3
8	*Lethane 60*-derris conc. 2 lbs.; *B1956* 4 oz.	19.8	32.3	52.1
9	*Lethane 60*-derris conc. 2 lbs.; *Oil 875* 2 pts.; *B1956* 4 oz.	5.5	11.3	16.8
10	Derris 2.5 lbs.; *Oil 875* 1 qt.; blood 2 oz.	2.2	1.0	3.2
11	Derris 2.5 lbs.; *Oil 875* 1 qt.; lead arsenate 8 oz.; *B1956* 4 oz.	2.9	1.6	4.5
12	Derris 2.5 lbs.; *Oil 875* 1 qt.; lead arsenate 1 lb. *B1956* 4 oz. (covers 2, 3 and 4) Derris 2.5 lbs.; *Oil 875* 1 qt.; *B1956* 4 oz. (covers 5 to 8)	3.7	1.6	5.3
13	Pyrethrum flowers 2 lbs.; *Oil 875* 1 qt.; blood 2 oz.	16.3	20.8	37.1
14	Pyrethrum flowers 4 lbs.; *Oil 875* 1 qt.; blood 2 oz.	13.8	11.3	25.1
15	*Pyrocide 20* 1 pt.; *Oil 875* 1 qt.; blood 2 oz.	17.0	17.5	34.5
16	*Pyrocide 20* 1 qt.; *Oil 875* 1 qt.; blood 2 oz.	6.3	8.0	14.3
17	Lead arsenate 3 lbs.; lime 3 lbs.; soybean flour 8 oz.	23.4	1.1	24.5
18	Checks, average of 3 trees	24.1	126.6[2]	150.7

[1] Eight cover sprays were applied as follows: 1—June 9, 2—June 22, 3—June 30, 4—July 8, 5—August 3, 6—August 12, 7—August 19, 8—August 28. All sprayed plats received 3 pounds of lead arsenate in the first cover spray, and the combinations indicated in the remaining seven covers except Plat 12.

[2] Average number of worm holes in each 100 apples.

[3] All plats were McIntosh variety except Nos. 3 and 5 which were Cortland.

variety Cortland showed considerable more codling moth injury than did the McIntosh. This is also shown by comparing Plats 4 and 5. Very good control was secured on Plat 6, table 2, treated with *Black Leaf 155* and oil.

A comparison of the fruit as it was removed from the trees indicated that the *Black Leaf 155* and oil seemed to leave a somewhat brighter and more highly colored finish on the fruit as compared with that sprayed with nitocine sulfate (*Black Leaf 40*) and oil.

Rotenone. As has been our experience for the past few years, powdered derris root again proved a very efficient insecticide for the codling moth. In table 1, Plat 10, excellent control was secured with a mixture of ground derris root and oil. With a thought toward making this spray toxic to apple maggot in addition to the codling moth, lead arsenate was added (Plats 11 and 12) in small amounts following a first cover containing 3 pounds of the arsenical. One-half pound of lead arsenate in each 100 gallons for the remaining cover sprays (Plat 11) left residues just over the tolerances for arsenic and lead. However, 1 pound in the 2nd, 3rd, and 4th covers in addition to 3 pounds in the 1st cover (Plat 12), left a spray deposit well within the tolerance at harvest Plats 2 and 3 in table 2 gave similar results.

In table 2, Plats 1 and 4 were treated with derris. No oil was used on Plat 1 and as a result the worm injury appeared to increase. On Plat 4 oil was used in two applications only and here the control was somewhat below that of the plats where oil was used in more of the cover sprays, Plats 2 and 3.

In preparing the ground derris root sprays the powdered root was first mixed into a paste with a small amount of water containing the spreading agent after which it dispersed readily in the water in the spray tank. The oil emulsion was added last.

A combination spray of 20 per cent by weight of *Lethane 60* and 80 per cent derris or cube (5 per cent rotenone), a Rohm & Haas product, was noticeably inferior to the other rotenone sprays as indicated in Plats 8 and 9 in table 1 and Plat 5 in table 2. Similar to results with other organic sprays, the addition of oil to the *Lethane*-derris mixture increased its efficiency, Plats 8 and 9 in table 1.

A spray program using lead arsenate and nicotine for the first brood and derris and oil for the second brood resulted in

Table 2.—Codling moth control on McIntosh apples with organic insecticides, 1942.

PLAT	MATERIALS USED AMOUNTS IN 100 GALLONS	COVER SPRAYS[2]	STINGS	DEEP WORM HOLES	TOTAL INJURY
1	Derris 2.5 lbs.; *Nu-Film* 1 pt.	3 to 8 incl.[1]	11.4%	6.6%	18.0%
2	Derris 2.5 lbs.; lead arsenate 8 oz.; *Nu-Film* 1 pt.	1, 2,			
	Derris 2.5 lbs.; lead arsenate 8 oz.; *Oil 875* 1 qt.; B1956 4 oz.	3 to 8 incl.	4.9	2.6	7.5
3	Derris 2.5 lbs.; lead arsenate 1 lb.; *Nu-Film* 1 pt.	1, 2,			
	Derris 2.5 lbs.; lead arsenate 1 lb.; *Oil 875* 1 qt.; B1956 4 oz.	3, 4,	4.7	1.4	6.1
	Derris 2.5 lbs.; *Oil 875* 1 qt.; *B1956* 4 oz.	5 to 8 incl.			
4	Derris 2.5 lbs.; *Oil 875* 2 qts.; *B1956* 4 oz.	3, 4,[1]	4.1	3.4	7.5
	Derris 2.5 lbs.; bentonite 2.5 lbs.; *SS3* 5 oz.	5 to 8 incl.			
5	*Lethane 60*-derris conc. 2 lbs.; *Oil 875* 3 pts.; *B1956* 4 oz.	3, 4,[1]	8.3	12.3	20.6
	Lethane 60-derris conc. 2 lbs.; *B1956* 4 oz.	5 to 8 incl.			
6	*Black Leaf 155* 3 lbs.; *Oil 875* 3 pts.; *SS3* 5 oz.	3 to 8 incl.[1]	7.6	2.3	9.9
7	*Pyrocide 20* 1 pt.; *Oil 875* 1 qt.; blood 2 oz.	3 to 8 incl.[1]	12.4	7.3	19.7
8	Pyrethrum flowers 3 lbs.; *Oil 875* 1 qt.; blood 2 oz.	3 to 8 incl.[1]	6.5	5.8	12.3
9	*Black Leaf 40* 0.75 pt.; lead arsenate 1 lb.; *SS3* 5 oz.	1 to 4 incl.	7.8	2.9	10.7
	Derris 2 lbs.; *Oil 875* 3 pts.; *SS3* 5 oz.	5 to 8 incl.			
10	Lead arsenate 3 lbs.; lime 3 lbs.; soybean flour 8 oz.	1, 2, 4, 5,[1]	10.4	4.7	15.1
11	Checks, average	none	6.2	100.3[3]	106.5

[1] Lead arsenate, 3 lbs. in 100 gallons was used in the first two cover sprays.
[2] Eight cover sprays were applied as follows: 1—June 9, 2—June 22, 3—June 30, 4—July 8, 5—August 3, 6—August 12, 7—August 19, 8—August 28.
[3] Average number of worm holes in each 100 apples.

good control of the codling moth, table 2, Plat 9. Apple maggot was not a serious problem in the experimental orchards, however, such a schedule might have possibilities for use against both codling moth and apple maggot and at the same time leave the fruit practically free of objectionable residues.

Pyrethrum, whether in the form of the ground flowers or the extract, was less effective than either nicotine or rotenone as appears in table 1, Plats 13, 14, 15 and 16, and table 2, Plats 7 and 8. Four pounds of the flowers were more effective than 2 pounds and similarly, 1 quart of *Pyrocide 20* was much better than 1 pint of this material.

Lead arsenate sprays performed in characteristic manner giving almost perfect control of worms but with a high percentage of stings, table 1, Plat 17. When four cover sprays were used as compared with eight applications on other plats, there was an increase in worm injury, however, the control would have been satisfactory in a commercial operation, table 2, Plat 10. As the spray program was arranged primarily to determine the value of organic insecticides in codling moth control, the interval between applications could very well have been lengthened for the more economical use of lead arsenate.

All treatments were applied at 7- to 10-day intervals, this being considered as the length of the protective period afforded by nicotine sprays when used against large populations of codling moth. Altho this point has not been definitely determined in the case of derris, experience suggests that the period of effective protection on apples is probably about the same as that afforded by nicotine sprays.

Spray residue from organic sprays such as bentonite-nicotine, ground derris root or ground pyrethrum flowers may appear spotted and unsightly on the fruit. To avoid such deposits which tend to result in uneven coloring of the fruit, special efforts were made to select and adjust a spreading agent so as to leave a smooth and unobjectionable residue. Several proprietary spreaders worked very satisfactorily with the organic materials. In the preparation of the sprays, the spreader was first added to water in the spray tank. The insecticide was then mixed into a paste using a small amount of water containing the spreader. The resulting paste was then poured into the water in the tank and the oil finally added. A spray so prepared with a suitable spreading agent produced a uniform film of liquid over the fruit and foliage resulting in a surprisingly even distribution of suspended material. The de-

Table 3.—Oil deposits on apple foliage from one per cent oil sprays using different spreading agents.[1]

SPREADER AND EMULSIFIER	MANUFACTURER	AMOUNT IN 100 GALLONS	MILLIGRAMS OF OIL DEPOSITED PER 100 SQ. IN.
Nu-Film	Miller Chem. & Fert. Corp.	16 oz. liquid	127
Grasselli, Spreader-Sticker	E. I. Du Pont	8 oz. liquid	120
Blood albumen	Armour & Company	2 oz. dry	109
B-1956	Rohm & Haas Company	4 oz. liquid	108
No spreader[2]			70

[1] Analyses made by A. W. Avens, Division of Chemistry.
[2] The oil was emulsified with Glycerol Oleate Edible A.

posit left on drying more closely resembled natural bloom on the fruit than ordinary spray residue. Color developed normally on fruit so sprayed without the blotchy effect so often encountered.

To evaluate the spreaders according to the amounts of material deposited, tests were made using an orchard sprayer at 400 pounds pressure. A 1 per cent summer oil was applied on Greening foliage using each of the several spreaders. Young trees with heavy succulent foliage were used for the tests and for this reason the oil deposits were possibly higher than would have been found on the foliage of older bearing trees. Determinations were made of the amount of oil laid down rather than of rotenone on account of the difficulties attending quantitative analyses for the latter material. Immediately after the spray dried 200 seven-eighth inch discs representing each treatment were cut from the foliage for analysis. The results expressed in milligrams of oil per 100 square inches of surface are given in table 3.

Judging from the results of the analyses, all four spreaders left appreciable deposits of oil and in approximately equal amounts. In comparison, the application without a spreader deposited about 40 per cent less oil. In other words, when certain spreading agents were incorporated with the oil sprays they made possible smooth and heavier deposits of oil, thereby avoiding unsightly spray residues and apparently providing for even more effective insect control.

CONCLUSION.—As a result of field tests with organic materials during the season of 1942 both nicotine and rotenone sprays again proved highly effective in combating the codling moth when applied every week or ten days during the period of codling moth activity. Nicotine was used both as the sulfate and as *Black Leaf 155*, while rotenone sprays were in the form of the powdered derris root. Pyrethrum sprays used both as the ground flowers and the extract gave some promise as a codling moth spray but were not as effective as either the nicotine or rotenone applications. Suitable spreading agents used with the insecticides allowed the fruit to color normally and left it free of objectionable visible residues.—2-17-43.

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WESLEY P. FLINT

Word has just been received of the death, on June 3, 1943, of Wesley P. Flint, at Urbana, Illinois.

Professor Flint had been, for many years, Entomologist of the Illinois Agricultural Experiment Station and for a similar period Chief Entomologist of the Illinois State Natural History Survey.

Professor Flint has always been very active in the affairs of our Association of which he served as president, and was properly considered one of the leaders of the entomological profession in America. News of his death will cause deep concern throughout our membership.

It is hoped that the JOURNAL may present an adequate account of his career in the next issue.

Lead Arsenate and Tricalcium Arsenate Combinations for the Control of Codling Moth[1]

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In the Doniphan County area of Kansas, the season of 1940 was characterized by severe spray burn to Jonathan apple foliage from the use of lead arsenate and lead arsenate combinations in the control of codling moth. This condition prevailed for all combinations of lead arsenate tested except where zinc sulfate was used with lead arsenate at the rate of 4 ounces to 100 gallons of water. Combinations of lead arsenate and soybean flour showed the most severe arsenical spray injury to foliage of all lead arsenate and adjuvants tested.

During the season of 1941,[2] zinc sulfate 4 ounces plus *Superla* summer oil 1 quart plus lead arsenate 4 pounds to 100 gallons of water was again included in the planned spray plots. While arsenical burn to Jonathan apple foliage was not so severe during the summer of 1941, at the end of the spraying season the zinc sulfate again showed its value as a safener for lead arsenate.

Zinc sulfate in combination with lead arsenate and summer oil emulsion was tested again during the season of 1942 for control of the codling moth and as a safener for lead arsenate when used on Jonathan foliage. Summer oil emulsion was used in a series of tests from the second through the fifth cover sprays to determine the effect upon arsenic residue removal at the end of the season. Lead arsenate alone without any safener was used on one series of tree replicates and two series of replicates were devoted to testing a lead arsenate-bentonite combination and "*Tritox*," a tricalcium arsenate-bentonite mixture. The tests were conducted in the experimental orchard of the Northeast Kansas Experiment Fields, Blair, Doniphan County, Kansas.

METHODS AND PROCEDURE.—Two-tree replicates of the Jonathan variety were used for each dosage and material to be tested. The replicates of each treatment and dosage were randomized throughout five rows of trees containing 10 trees to the row.

Plot 1.—The two trees of this plot were sprayed all through the spray season with 4 pounds of *Tritox* to 100 gallons of water with no sticking agent used.

Plot 2.—The two trees of this plot were sprayed with 4 pounds of lead arsenate plus 2 ounces of bentonite to 100 gallons of water throughout the season.

Plot 3.—This plot of 2 trees was sprayed throughout the season with 4 pounds of lead arsenate alone to 100 gallons of water.

Plot 4.—This two-tree plot was sprayed with 4 pounds of lead arsenate plus 1 quart of *Superla* oil emulsion plus 4 ounces of zinc sulfate through the second cover spray. The third cover through ninth cover spray had 4 pounds of lead arsenate plus 4 ounces of zinc sulfate to 100 gallons of water with no oil.

Plot 5.—This two-tree plot was sprayed with 4 pounds of lead arsenate plus 1 quart of *Superla* oil emulsion plus 4 ounces of zinc sulfate to 100 gallons through the third cover spray. The fourth cover spray through the ninth cover had 4 pounds of lead arsenate plus 4 ounces of zinc sulfate to 100 gallons of water with no oil.

Plot 6.—This two-tree plot was sprayed with 4 pounds of lead arsenate plus 1 quart *Superla* oil emulsion plus 4 ounces of zinc sulfate to 100 gallons through the fourth cover spray. The fifth through ninth cover sprays had 4 pounds of lead arsenate plus 4 ounces of zinc sulfate to 100 gallons of water with no oil.

Plot 7.—This two-tree plot was sprayed with 4 pounds of lead arsenate plus 4 ounces of zinc sulfate plus 1 quart of *Superla* oil emulsion to 100 gallons through fifth cover spray. The sixth through ninth cover sprays had 4 pounds of lead arsenate plus 4 ounces of zinc sulfate to 100 gallons of water with no oil.

Dropped apples were picked up at intervals during the summer, counted and scored for worms and stings. The pre-harvest dropped apples to the number of 250 per tree were counted and scored for

[1] Contribution No. 519 from the Department of Entomology.
[2] Parker, Ralph L. and Lamerson, Paul G. Lead arsenate and lead arsenate-zinc sulfate-summer oil combinations as sprays for the control of codling moth during the season of 1941. Manuscript.

worms and stings from September 4 to 7. A storm the night of September 14 made necessary the picking up and scoring of 250 fruits per tree for worms and stings. This was designated as the harvest count, since following this storm many trees of the plot concerned in the tests had fewer than 250 fruits remaining on the trees.

The oil was omitted from the second to the fifth cover sprays in a series of lead arsenate-zinc sulfate-summer oil plots to determine whether residue difficulties of the 1941 season would be encountered again at the end of the 1942 season. In making the arsenic residue analyses the apples were washed 2½ minutes, stirring continuously in a 3 per cent (by volume) concentrated hydrochloric acid in tap water. The temperature of the wash solution was raised to 35° C. before the apples were added.

Bordeaux mixture 1-2-50 was added to the sixth cover spray on July 23, to help control Jonathan leafspot, also called frogeye or blackrot.

SEASONAL CONDITIONS AND CODLING MOTH ABUNDANCE—*First Brood.*—The first moths from the overwintering generation of larvae were caught in bait traps on May 13. Cool nights and unseasonably cool days tended to reduce the number taken in the bait traps during the first part of the moth emergence season. The first worm entries from first brood larvae were noted on May 26. This was seven days later than for the season of 1941. The heaviest hatch of worms occurred from June 13 to 15. By June 1, the catches of overwintering brood moths began to diminish. The interval from June 15 to 22 was one of unseasonably cool nights and small bait trap catches. There was a pronounced depression in moth population between the first and second broods. From June 22 to July 15, variable weather conditions resulted in a prolonged and slow emergence of the first brood moths.

Second Brood.—On July 15, bait trap catches indicated that the first brood moths were emerging. On July 17, emergence of first brood moths was confirmed by moths appearing in the emergence cage. This emergence date was fully two weeks later than for the season of 1941. Cool nights held down the catches of moths in bait traps from July 20 to 25. The heaviest hatch of worms of the second brood occurred during the interval from August 10 to September 10. Injury to fruit by the first half of the second brood was light. Injury to fruit by the last part of the second brood was extremely heavy, the heaviest damage of the season.

Third Brood.—As far as it was possible to determine, there was no third brood of worms. Worms found late in the season probably were from a prolonged second-brood moth emergence which had been delayed fully 2 weeks later than normal.

SEASONAL DAMAGE.—The codling moth season of 1942 was characterized by a light, easily controlled first brood, the activity of which was held down by unfavorable weather conditions.

The beginning of the second brood was 2 weeks later than for the season of 1941. Since the last half of this brood found weather conditions favorable for its development, there resulted, from August 20 to September 10 the heaviest worm damage of the season.

Due to plentiful rains, cool nights and irregular warm weather conditions, bait trap catches, in terms of numbers of moths caught, were not a reliable index of damage to be expected during the season of 1942.

The last three sprays of the season of 1942 were the more important sprays for protecting the crop from the heavy hatch of late worms. Severe damage to fruit can result from late worms even when the control of first brood worms appears to have been highly successful.

Materials and Dosages.—The insecticide combinations used are indicated in table 1.

Information in regard to spray dates was gathered from two sets of codling moth bait traps, or a total of 20 traps. One set of 10 traps was located at the Blair experiment orchard, Blair, Kansas, and the other set at the Frank Lehman orchard, Wathena, Kansas. This pertinent information was furnished to growers by the Doniphan County Farm Bureau, Troy, Kansas. Spray dates for the 1942 season were as follows: Calyx, May 7; first cover, May 19; second cover, May 29; third cover, June 6; fourth cover; June 22; fifth cover, July 15; sixth cover, July 23; seventh cover, August 5; eighth cover, August 19; and ninth cover, August 31.

RESULTS.—In recording the data of injured fruits, multiple stings or worms in any one fruit were not considered. When a

Table 1.—Kinds and quantities of insecticides used in the control tests in pounds per 100 gallons of spray mixture.

TREATMENT
1. *Tritox*—4 pounds.
2. Lead arsenate, 4 lbs. plus 2 oz. Wyoming bentonite.
3. Lead arsenate, 4 lbs. (all cover sprays, 9).
4. Lead arsenate, 4 lbs. plus *Superla* summer oil emulsion 1 qt. plus zinc sulfate ($ZnSO_4$), 4 oz. through second cover spray. Oil left out of third through ninth cover sprays.
5. Lead arsenate, 4 lbs. plus *Superla* summer oil emulsion 1 qt. plus zinc sulfate ($ZnSO_4$), 4 oz. through third cover spray. Oil left out of fourth through ninth cover sprays.
6. Lead arsenate, 4 lbs. plus *Superla* summer oil emulsion 1 qt. plus zinc sulfate ($ZnSO_4$), 4 oz. through fourth cover spray. Oil left out of fifth through ninth cover sprays.
7. Lead arsenate, 4 lbs. plus *Superla* summer oil emulsion 1 qt. plus zinc sulfate ($ZnSO_4$), 4 oz. through fifth cover spray. Oil left out of sixth through ninth cover sprays.

fruit had stings and worms present, such fruit was placed in the "wormy" category.

The arsenical burn of foliage was determined by comparative observation of leaf color or injury and the retention of foliage at the end of the growing season. The plot sprayed with *Tritox* had the most severe arsenical burn of foliage (75 per cent). The plot sprayed with lead arsenate-bentonite had the next most seriously injured foliage (65 per cent). The lead arsenate alone plot had 50 per cent foliage injury through the season. The lead arsenate-summer oil-zinc sulfate treated plots had the least amount of arsenical burn of leaves of all the plots and the leaves remained in a normal condition on the trees until frost.

Data of the various insecticide tests for the control of codling moth in the Blair experimental orchard at Blair, Kansas, are recorded in tables 2 to 6:

GENERAL OBSERVATIONS.—Dropped apples were counted during the summer on July 17 and 31 and August 21. A windstorm July 13 made clean, dropped apples of the first count of no significance and only the wormy fruits were counted. Most of the clean dropped apples counted on July 31 were knocked from the branches by the spray rig.

A week to two weeks previous to the time of harvest excessive dropping of mature fruit takes place if the weather is hot following a period of abundant moisture and this fruit is known as the pre-harvest crop. The preharvest drop of Jonathan apples was the worst in many years. Many growers picked up two-thirds of the crop from the ground.

DISCUSSION.—The objects of the tests of the spray materials for the season of 1942 were to determine the effectiveness in the control of codling moth, the relative freedom from spray injury of the foliage at the end of the spray season and the effect of oil upon arsenic residue removal when used through the fifth cover spray.

Arsenic tolerance is 0.025 grains of arsenic per pound of apples, which is allowed by the Federal Security Agency. The use of oil in the fourth and fifth cover sprays increases the difficulty of removing the arsenic load from the harvested apples by the standard acid wash (Table 6).

On August 5 a leaf-miner outbreak was noted to be well under way. This pest burrows beneath the epidermis of the leaf and feeds upon the leaf tissues between the epidermis. When the larva has completed its feeding period, it leaves the leaf by lowering itself to the ground by means of a thread. This skeletonizing of the leaves infested by leaf miners causes additional arsenical burning, resulting in much loss of foliage. An infestation of Jonathan leafspot or frogeye disease was also present during the 1942 season and contributed further foliage injury.

All materials tested except the tricalcium arsenate-bentonite combination gave effective control of codling moth. Some variations in the percentages of control expected occurred in the zinc sulfate-lead arsenate-summer oil tests. The plot receiving two summer oil sprays rated a higher percentage of effectiveness in control than the plots receiving three and four summer oil sprays. These variations in percentage of control obtained were of a 6 per cent spread between the most effective and the least effective of the lead arsenate-zinc sulfate-summer oil plots.

SUMMARY.—The tricalcium arsenate-bentonite plot was the least effective of all the spray combinations tested. Only 34.1 per cent of clean fruit resulted from the use of this material. Arsenical burn was more severe on the foliage of this plot than it was with any of the other spray combinations tested.

The lead arsenate-bentonite mixture was slightly more effective in codling moth control than was lead arsenate alone. The foliage injury however, was less than for the tricalcium arsenate-bentonite treatment.

Table 2.—Percentages of wormy, stung and clean apples dropped during summer (to August 21).

Insecticide Treatment in Pounds per 100 Gallons Gallons of Water	Total Number per Plot	Wormy		Stung		Clean	
		Number per Plot	Per Cent	Number per Plot	Per Cent	Number per Plot	Per Cent
Tritox 4 lbs.	172	69	40.1	9	5.2	94	54.7
Lead arsenate 4 lbs. plus Wyoming bentonite 2 oz.	142	32	22.5	2	1.4	108	76.1
Lead arsenate 4 lbs.	92	23	25.0	5	5.4	64	69.6
Lead arsenate 4 lbs. plus *Superla* oil 1 qt. plus zinc sulfate 4 oz. Oil left out after 2nd cover spray	102	25	24.5	1	1.0	76	74.5
Lead arsenate 4 lbs. plus *Superla* oil 1 qt. plus zinc sulfate 4 oz. Oil left out after 3rd cover spray	140	19	13.6	2	1.4	119	85.0
Lead arsenate 4 lbs. plus *Superla* oil 1 qt. plus zinc sulfate 4 oz. Oil left out after 4th cover spray	189	33	17.5	2	1.0	154	81.5
Lead arsenate 4 lbs. plus *Superla* oil 1 qt. plus zinc sulfate 4 oz. Oil left out after 5th cover spray.	104	18	17.3	3	2.9	83	79.8

Table 3.—Preharvest dropped apple counts, September 4 to 7, 1942; and percentages of wormy, stung and clean apples.

Insecticide Treatment in Pounds per 100 Gallons of Water	Total Number per Plot	Wormy		Stung		Clean	
		Number per Plot	Per Cent	Number per Plot	Per Cent	Number per Plot	Per Cent
Tritox 4 lb.	500	162	32.4	187	37.4	151	30.2
Lead arsenate 4 lbs. plus Wyoming bentonite 2 oz.	500	5	1.0	70	14.0	425	85.0
Lead arsenate 4 lbs.	500	13	2.6	82	16.4	405	81.0
Lead arsenate 4 lbs. plus *Superla* oil 1 qt. plus zinc sulfate 4 oz. Oil left out after 2nd cover spray	500	13	2.6	71	14.2	416	83.2
Lead arsenate 4 lbs. plus *Superla* oil 1 qt. plus zinc sulfate 4 oz. Oil left out after 3rd cover spray	500	8	1.6	51	10.2	441	88.2
Lead arsenate 4 lbs. plus *Superla* oil 1 qt. plus zinc sulfate 4 oz. Oil left out after 4th cover spray	500	31	6.2	66	13.2	403	80.6
Lead arsenate 4 lbs. plus *Superla* oil 1 qt. plus zinc sulfate 4 oz. Oil left out after 5th cover spray	500	5	1.0	60	12.0	435	87.0

Table 4.—Harvest counts,[1] September 15 and 16, 1942; and percentage of wormy, stung and clean apples.

Insecticide Treatment in Pounds per 100 Gallons of Water	Total Number per Plot	Wormy		Stung		Clean	
		Number per Plot	Per Cent	Number per Plot	Per Cent	Number per Plot	Per Cent
Tritox 4 lbs.	500	115	23.0	231	46.2	154	30.8
Lead arsenate 4 lbs. plus Wyoming bentonite 2 oz.	500	3	0.6	114	22.8	383	76.6
Lead arsenate 4 lbs.	500	9	1.8	98	19.6	393	78.6
Lead arsenate 4 lbs. plus *Superla* oil 1 qt. plus zinc sulfate 4 oz. Oil left out after 2nd cover spray	500	5	1.0	97	19.4	398	79.6
Lead arsenate 4 lbs. plus *Superla* oil 1 qt. plus zinc sulfate 4 oz. Oil left out after 3rd cover spray	500	3	0.6	73	14.6	424	84.8
Lead arsenate 4 lbs. plus *Superla* oil 1 qt. plus zinc sulfate 4 oz. Oil left out after 4th cover spray	500	9	1.8	87	17.4	404	80.8
Lead arsenate 4 lbs. plus *Superla* oil 1 qt. plus zinc sulfate 4 oz. Oil left out after 5th cover spray	500	7	1.4	77	15.4	416	83.2

[1] A severe storm the night of September 14 shook off nearly all of the crop. The apples counted were 250 per tree and all were on the ground.

Table 5.—Summary of all apple counts for season of 1942, and percentage of wormy, stung and clean apples.

Insecticide Treatment in Pounds per 100 Gallons of Water	Total Number per Plot	Wormy		Stung		Clean	
		Number per Plot	Per Cent	Number per Plot	Per Cent	Number per Plot	Per Cent
Tritox 4 lbs.	1172	346	29.5	427	36.4	399	34.1
Lead arsenate 4 lbs. plus Wyoming bentonite 2 oz.	1142	40	3.5	186	16.3	916	80.2
Lead arsenate 4 lbs.	1092	45	4.1	185	16.9	862	79.0
Lead arsenate 4 lbs. plus *Superla* oil 1 qt. plus zinc sulfate 4 oz. Oil left out after 2nd cover spray	1102	43	3.9	169	15.3	890	80.8
Lead arsenate 4 lbs. plus *Superla* oil 1 qt. plus zinc sulfate 4 oz. Oil left out after 3rd cover spray	1140	30	2.6	126	11.1	984	86.3
Lead arsenate 4 lbs. plus *Superla* oil 1 qt. plus zinc sulfate 4 oz. Oil left out after 4th cover spray	1189	73	6.2	155	13.0	961	80.8
Lead arsenate 4 lbs. plus *Superla* oil 1 qt. plus zinc sulfate 4 oz. Oil left out after 5th cover spray	1104	30	2.7	140	12.7	934	84.6

Table 6.—Residue analyses of apples from calcium and lead arsenate spray plots.[1]

Treatment in 100 Gallons of Water	Grains Arsenic (As_2O_3) per Pound of Apples	
	Before Washing	After Washing
Lead arsenate 4 lbs., *Superla* oil 1 qt., zinc sulfate 4 oz. Oil left out after 5th cover spray	0.2650	0.025
Lead arsenate 4 lbs., *Superla* oil 1 qt., zinc sulfate 4 oz. Oil left out after 4th cover spray	0.2580	0.023
Lead arsenate 4 lbs., *Superla* oil 1 qt., zinc sulfate 4 oz. Oil left out after 2nd cover spray	0.3825	0.02
Lead arsenate 4 lbs., *Superla* oil 1 qt., zinc sulfate 4 oz. Oil left out after 3rd cover spray	0.2163	0.015
Lead arsenate 4 lbs., Wyoming bentonite 2 ounces	0.3303	0.01
Lead arsenate 4 lbs.	0.2660	0.009
Tritox 4 lbs. (calcium arsenate-bentonite)	0.2447	less than 0.001

[1] Residue analyses were made by Dr. B. L. Smits of the Department of Chemistry, Kansas State College.

The spread in effective control obtained on the 4 lead arsenate-zinc sulfate-summer oil emulsion plots ranged from 80.8 to 86.3 per cent clean fruit. The foliage on all these plots had less arsenical burn than on the plots sprayed with tricalcium arsenate-bentonite, lead arsenate-bentonite, or lead arsenate alone. Less defoliation took place on the lead arsenate-zinc sulfate-summer oil emulsion plots than on the other plots.

The percentage spread in effective control of codling moth of the best lead arsenate-zinc sulfate-oil plot over lead arsenate alone was 7.3 per cent. The percentage spread of wormy fruit on all plots containing some combination of lead arsenate ranged from 3.5 to 6.2 per cent. The percentage spread of stung fruits ranged from 11.1 to 16.9 per cent.

Fewer stung fruits resulted on the plots receiving the greater number of lead arsenate-zinc sulfate-summer oil emulsion sprays. The stings on all plots containing some combination of lead arsenate were light, and most of them were well healed over, difficult to observe and left fruit usable at harvest.

A disadvantage was apparent for all of the zinc sulfate plots in that the fruit which matured later, due to foliage excellence, had less color and appeared less desirable when compared to the better colored fruit on the tricalcium arsenate-bentonite, lead arsenate-bentonite and lead arsenate alone plots. However, one orchardist in Doniphan County used the lead arsenate-zinc sulfate-summer oil emulsion combination. When the Jonathan variety began to drop rapidly, this grower sprayed with one of the hormone sprays. This resulted in the fruit remaining on the tree until adequate color was obtained.

All samples of harvested apples, when analyzed for arsenical residue, had more than the tolerance of 0.025 grains of arsenic per pound of fruit. The acid wash reduced all of them to the tolerance or below it. The lead arsenate-zinc sulfate-summer oil combination with 5 oil sprays, when washed, still bore a residue of 0.025 grains of arsenic per pound of fruit.—11-17-42.

Literature Cited

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Studies of Reduced Schedules for Control of Apple Insects in Connecticut[1]

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Experiments with reduced schedules were begun at the Connecticut Station several years ago in order to meet, if possible, the growing demand for lower cost of production. While not yet complete, our results so far are given in the hope that they may be of some benefit to others working in this field.

More than 10 years ago Stoddard and Zappe began experimenting with lime-lead arsenate-fish oil spray mixtures, the oil supposedly serving as a sticker. This combination was reported to yield good fruit at the Mount Carmel farm on varieties not subject to scab. It left no objectionable residue at harvest, but foliage injury was noted from time to time, and during the very wet season of 1938 results in outlying orchards were not too favorable.

We began then to investigate the actual sticking properties of the mixture. It was found that such materials as aluminum sulfate with lime stuck on the arsenate fully as well as the fish oil and gave good insect control with less foliage injury. Having assumed, however, that lime in the mixture was partly responsible for removal of the arsenical as well as foliage drop in the ones containing fish oil, it became desirable to eliminate it, if possible, so other aluminum salts were tested. Aluminum acetate gave promise, being safe without lime, which the sulfate is not, and it was found that by mixing a small amount of benzoic acid (2 to 3 oz.) with the aluminum acetate (later found to be aluminum aceto-borate) a soapy solution resulted, probably due to the formation of aluminum hydroxide gel. In this mixture we were able to emulsify white summer oils, which we did in field tests, adding the regular acid lead arsenate, 3 pounds to the hundred. We were agreeably surprised to see the mixture remain on the trees for a long time entirely without foliage burn, even in wet weather. Compared with western "dynamite" mixtures, the adhesion was fully as good if not better, and the foliage was in much better condition at the end of the season. Insect control seemed to be satisfactory even for apple maggot, for which the spray was not applied. It was then thought that the combination might be used to reduce the *number* of applications, possibly by increasing the dosage early and omitting later sprays altogether. This was done in 1941 and 1942. While the insect control is not quite as good as with more frequent and extended spraying, the results are remarkably close as far as insect control is concerned. This year fruit russetting was much less than in plots with sulfur-lime-lead arsenate sprays.

Because of the war we are no longer able to get powdered aluminum aceto-borate, but only aluminum acetate solutions. One of the latter, aluminum aceto-formate (24 per cent), was obtained in 1942. This solution is not as safe as aluminum aceto-borate on foliage, nor can we get the soapy reaction with benzoic acid. With more experimentation we found that a small amount of manganese borate added to the solution together with some benzoic acid gives a mixture suitable for emulsifying oil. This combination was used in 1942 with fairly satisfactory results. It was checked against standard sulfur arsenical sprays as well as a lime-talc-oil combination and an oil-lead arsenate spray. Adhesion was about equal to the oil-lead arsenate combination but the foliage was much better, indicating again the safening value of possibly the aluminum hydroxide.

In the meantime, by laboratory tests we were able to prove that alumina gel by itself could be used for emulsifying oils, and also that it has good adhesive properties. Being unable to obtain alumina gel because of the war, that is, without too much red tape, silica gels were tried in their place. These also have good adhesive properties and it seems possible that other gels of the same nature are sometimes formed in spray mixtures. With the silica solution used (a commercial product), it is very easy to make gels with lime, copper sulfate, or even nicotine sulfate. Several mixtures of this type that proved to be

[1] Eastern Branch Program, New York, November, 1942.

good in the laboratory were tried in the field on apple trees. They did not give the adhesion obtained with those mixtures containing oil. None except talc and lime compares with aluminum aceto-borate-lead arsenate-oil in condition of the fruit and foliage at the end of the season.

Realizing that fungicides are needed in any complete apple spray for our locality, and knowing that oils and sulfurs do not combine satisfactorily, experiments were begun with other fungicides. One of these, chloranil, gives some promise, although tests in 1941 indicate that it has a tendency to russet fruit of tender varieties.

Table 1.—Summary of glass slide sticker tests. Percentages are to the nearest whole numbers.

MATERIAL	NO. TESTS	PER CENT LOSS
Lead arsenate 3 gms. to 205 cc.	8	57
Lead arsenate 3 gms. + lime 3 gms. to 205 cc.	2	44
Lead arsenate 3 gms. + skim milk 2 gms. to 205 cc.	2	41
Lead arsenate 3 gms. + flour 4 gms. to 205 cc.	2	28
Lead arsenate 3 gms. + talc 3 gms. + lime 3 gms. to 205 cc.	4	26
Lead arsenate 3 gms. + Bentonite 3 gms. + lime 3 gms. to 205 cc.		26
Lead arsenate 3 gms. + lime 3 gms. + oil 6 cc. to 205 cc.	2	20
Lead arsenate 3 gms. + bentonite-sulfur 3 gms. + lime 3 gms. to 205 cc.	4	19
Lead arsenate 3 gms. + alumina gel[1] 3 gms. to 205 cc.	6	16
Lead arsenate 3 gms. + white oil[2] 6 cc. to 205 cc.	2	15
Lead arsenate 3 gms. + alumina gel 3.5 gms. + sulfur 3 gms. to 205 cc.	2	15
Lead arsenate 3 gms. + talc 3 gms. + lime 3 gms. + oil 6 cc. to 205 cc.	8	10
Lead arsenate 3 gms. + silica solution[3] 3 cc. + lime 3 gms. to 205 cc.	4	10
Lead arsenate 3 gms. + talc 3 gms. + alumina gel 3 gms. to 205 cc.	2	9
Lead arsenate 3 gms. + alumina gel 3 gms. + white oil 6 cc. to 205 cc.	2	8
Lead arsenate 3 gms. + talc 3 gms. + alumina gel 6 gms. + sulfur 3 gms. to 205 cc.	3	6

[1] Aluminum hydroxide 5 to 8% Al_2O_3.
[2] Socony *Tecktol*.
[3] Commercial colloidal silica solution.

Whether this would be serious enough to make much difference, or whether reduced dosages could be used in wet weather is not known. There are available several other fungicides that appear to be compatible with oil. None have been field tested extensively enough to permit any conclusions. The argument usually advanced against reduced schedules is that continual development of scab on new foliage and infection of the fruit therefrom makes control by this means difficult or doubtful. Theoretically, at least, fruit kept covered by spray throughout the season should be protected, and preliminary experiments in 1941 indicated a definite possibility in this direction.

Because of the very good adhesion of lime sulfur on apple, and because of its caustic action, we began work with it, hoping to retain the adhesion and eliminate the injury. Catalytic safeners offered a very definite improvement, and with modifications utilizing manganese sulfate we were able to apply lime sulfur mixtures with reasonable safety. However, the fruit of many varieties was often of poor finish. Laboratory tests showed us that solutions containing manganese borate, sulfur and lead arsenate remained alkaline for a long time, much longer in fact than those containing manganese sulfate. For 2 years now we have tested solutions containing lime sulfur, lead arsenate, soybean flour and manganese borate with very good results on McIntosh and Baldwin. On Baldwins the lime sulfur should be reduced to at most 1 gallon per 100, which makes a fairly cheap fungicide, but should probably not be applied after June 15. One commercial orchardist in Wallingford sprayed approximately four acres of McIntosh with good results while we have had under test for 2 years about one-half acre of mixed varieties. It will be recognized that this safener contains two important minor elements reported to be of value in fertilizers and may be of actual value to the trees themselves.

As to practical applications, it is believed that oils as stickers can be easily marketed as emulsions in alumina gel, or with aluminum aceto-borate and benzoic acid as soon as the war is over. In the meantime, it is interesting to note the adhesive properties of talc and lime which appear to be good, both in the field and the laboratory, and the silica gels from silica solutions produced by addition of salts such as copper sulfate, nicotine sulfate and others. Also, it is believed that the lead arsenate-lime sulfur-flour-manganese borate mixture is a good apple spray, possibly of value in the conservation of lead arsenate.

DISCUSSION OF TABLES.—In the slide sticker tests, table 1, ordinary lantern slides were cleaned in soap and water, rinsed, wiped with paper towels and dried over calcium chloride. The various mixtures were settled onto the slides in a settling tower to give a uniform coating. Washing was accomplished by immersion in distilled water (20 to 22° C.) and moving back and forth 20 times (10 times each

way). After again drying over calcium chloride, weights were taken and the loss computed. The various mixtures are more concentrated than used in the field, but the relative proportion of ingredients is approximately the same. Variation was not great, usually ± 5 per cent, but the tests do not equal a field or plant experiment. The figures indicate only the initial

Table 2.—Analysis showing adhesion of 1942 mixtures.[1]

	Micrograms As_2O_3 per 100 sq. cm. Discs[2]				
	6/16	7/3	8/1	9/1	Fruit Residue 9/15 grs. per Pound
Lead arsenate—flotation sulfur	984	703	669	564	.008
Lead arsenate—oil	2838	2312	1548	1053	.014
Lead arsenate—talc—lime—oil	2264	1613	952	614	.010
Lead arsenate—aluminum aceto-formate—oil	3089	2442	1722	1087	.013

[1] Applications—No. 1: May 1, 16, 27, June 9, July 7—Lead arsenate 3 lbs. = 100 in all sprays. Nos. 2–4: May 1, 15, June 8–9—Lead arsenate 3 lbs = 100 in first, 6 lbs. = 100 in last two sprays. Rainfall June 16–Sept. 1, 12.76 inches.
[2] Analyses by C. E. Shepard.

amounts removed and probably should not be compared with field tests where weathering occurs over an extended period.

Table 2 shows adhesion in field experiments during 1942. Four different mixtures were used. The data show that the aluminum acetate formula was no better in adherence than lead arsenate and oil.

Table 3.—Analysis showing adhesion of dynamite mixture compared with modified mix with aluminum aceto-borate 1940.[1]

	Micrograms As_2O_3 per 100 sq. cm. Discs				
	6/16	7/16	8/16	9/16	Per Cent Remaining
Western Dynamite	2858	2571	1931	1612	56.4
Modified formula[2]	2331	2571	2000	1725	74.0

[1] Applications—May 17, 29, June 12. Rainfall June 16–Sept. 16, 8.66 inches.
[2] Aluminum aceto-borate, benzoic acid, oil and lead arsenate.

The load on these trees was higher throughout the season than in the lead arsenate-flotation sulfur plot, which probably accounts for the good insect control shown in table 5.

Table 3 is a comparison of adhesive properties using dynamite and a modified formula containing aluminum aceto-borate and white lubricating oil. There was somewhat better adhesion with the latter

Table 4.—Comparison of maggot control 1941. Per Cent infested

Variety	I Sulfur Lead Arsenate	II Lead Arsenate Oil Aluminum Aceto-Borate
Greening	4.94	1.60
King	25.81	6.21
Spy	22.31	5.39
Pippin	22.94	.72
Sutton	3.53	1.90
Russet	4.42	2.56

than with western dynamite. The foliage was also much improved.

Table 4 shows much better control of apple maggot in 1941 with a 3-spray

Table 5.—Comparison of curculio control with 3- and 4-spray schedules 1941. Percentages of marked fruit

Trees Compared	Sulfur Lead Arsenate 4 Sprays	II Lead Arsenate Aluminum Aceto-borate Oil
A4 & A5	14.01	38.02
C4 & C5	3.13	4.44
A14 & A15	2.52	17.18
D3 & C3	6.47	3.32
D7 & C7	2.38	1.04
D8 & D9	1.04	1.25

schedule containing aluminum aceto-borate and oil as compared with a 4-spray schedule with sulfur and lead arsenate.

Table 5 gives a direct comparison in curculio control of the two mixtures.

Table 6 shows scab control. The varieties included are non-scab varieties. Those subject to scab were much worse in the case of number II.

Table 6.—Comparison of scab control. Percentages free of scab 1941

Trees Compared	I Sulfur Lead Arsenate 4 Sprays	II Lead Arsenate Aluminum Aceto-borate Oil 3 Sprays
A4 & A5	77.73	59.29
A14 & A15	95.08	80.98
B14 & B15	87.03	94.63
D8 & D9	97.42	97.25
D10 & D11	97.25	96.96

Table 7 gives a comparison of fruit free of insect marks, comparing a 5-spray sulfur-lead arsenate schedule with one having only three sprays.

Table 7.—Comparison of a 3-spray schedule with one containing 5 sprays, 1942.
Percentages of insect-free fruit (except aphis)

Trees Compared	I Lead Arsenate Aluminum Aceto-Formate Oil	II Sulfur Lead Arsenates
A2 & A3	96.10	98.72
B2 & B3	94.55	98.21
C2 & C3	97.26	98.65
E6 & E7	91.23	90.47
D6 & D7	77.96	92.99
D13 & D12	95.05	83.90

Table 8 is a continuation of table 5, but showing insect free fruit.

Table 9 is a comparison of four formulae and two schedules, showing the increased

Table 8.—Comparison of a 3-spray schedule with one containing 5 sprays, 1942.
Percentages of insect-free fruit (except aphis)

Trees Compared	III Lead Arsenate Oil	II Sulfur Lead Arsenate
A5 & A4	92.49	97.02
B5 & B4	96.75	98.15
C5 & C4	91.00	98.51
D15 & D12	75.50	83.90
E4 & E7	95.55	90.47

amount of fruit russet from the lead arsenate-flotation sulfur formula. Number IV was sprayed 5 times, and numbers I to III only 3 times during the season. In the 3-spray schedule, lead arsenate was used twice at 6 pounds per 100 gallons, and once at 3 pounds. In the 5-spray schedule it was used at 3 pounds throughout. This gives the same *amount* of arsenate applied in the two series with some slight differences due to varying quantities of foliage at the different periods.

Table 9.—Comparison of standard spray schedule with 3-spray program. Effect of sprays on fruit russetting and foliage burn—1942.

Treatment	Per Cent Conspicuous Russet on Baldwin	Foliage Burn
I Lead arsenate—aluminum aceto-formate—oil	8.91 7.76	Slight
II Lead arsenate—flotation sulfur	40.40 34.74	None to slight
III Lead arsenate—oil	21.41 14.85	Moderate
IV Lead arsenate—lime—talc—oil	8.04 8.57	Heavy (some defoliation)

SUMMARY.—Tests on glass slides in the laboratory, utilizing the settling tower and washing in distilled water, indicate that both silica and alumina gels have good adhesive properties. They indicate furthermore that lime added to talc and certain other materials may increase the adhesiveness of the mixture. They indicate that complete mixtures containing sulfur as the fungicide still have good adhesion when combined with alumina gel.

Field tests in 1941 and 1942 indicated the value of aluminum aceto-borate or aluminum aceto-formate, oil and benzoic acid (probably forming alumina gels) as stickers and that such mixtures have a definite corrective or "safening" value for arsenate of lead. This is reflected in both reduced foliage drop and fruit russet. The important problem of introducing a satisfactory fungicide into the special mixtures is still unsolved.

Orchard experiments with lime sulfur, soybean flour and manganese borate have also given interesting results. The combination produced good quality fruit relatively free of russet, in at least two different Connecticut orchards.—12-18-42.

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R. W. THOMPSON

R. W. Thompson, Ontario Agricultural College, Guelph, is acting head of department there in the absence of Lt. Commander Baker and Major Ozburn. Mr. Thompson is a member of the Royal Canadian Naval Volunteer Reserve.

Experiments with the Peach Tree Borer in North Carolina[1]

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The work with the peach tree borer was started in the fall of 1939 with the view of investigating the following points under North Carolina conditions:

(1) Relative effectiveness of ethylene dichloride emulsion and paradichlorobenzene.
(2) Best time to apply control measures for the peach tree borer.
(3) Necessity of mounding when using ethylene dichloride emulsion.
(4) Size of mound if mounding is necessary.
(5) Necessity of tamping mound with the back of the shovel.
(6) Effect of ethylene dichloride emulsion or paradichlorobenzene on peach trees.

MATERIALS USED AND METHODS OF APPLICATION.—Paradichlorobenzene was used in the crystalline form and, in a limited number of cases, dissolved in oil (*Scalecide* plus 15 per cent paradichlorobenzene). All the grass, weeds and rubbish were removed from around the tree and then soil was piled up 2 to 3 inches around the trunk of the tree in order to have the paradichlorobenzene above most of the borers. A ring was then made in this loose soil 1 to 2 inches from the trunk of the tree. The paradichlorobenzene was placed in the ring around the tree and covered with 3 or 4 shovelfuls of soil. Paradichlorobenzene was used at the following amounts, *i.e.* trees 6 years old and older —1 oz.; 4 and 5 years—0.75 oz.; 3 years—0.5 oz.; 2 years—0.25 oz.; 1 year—0.125 oz.

Ethylene dichloride emulsion[2] was used in 2 different ways. (1) The crust of the soil was broken immediately around the tree to prevent excessive run-off of the material. The ethylene dichloride emulsion was then poured on the base of the tree but the tree was *not* mounded; (2) the treatment was made as above and then the material was covered with 2 to 4 shovelfuls of soil.

Unless indicated otherwise ethylene dichloride emulsion was used at the following dilutions: Trees six years and older, 0.5 pint of 25 per cent emulsion; 4 and 5 year old trees, 0.5 pint of 20 per cent emulsion; 3 year old trees 0.5 pint of 15 per cent emulsion; 1 and 2 year old trees 0.125 pint of 7.5 per cent emulsion.

Checks. Trees were left untreated in the plot of trees of each age at each date of treatment. These trees were then checked when the treated trees were checked.

TIME OF APPLICATION AND MATERIAL USED.—(Table 1). Results of tests (1939–40) to determine best time to treat peach trees, value of mounding, and comparative value of paradichlorobenzene and ethylene dichloride emulsion. Numbers represent total number of borers found in 10, 7 year old trees in May, 1940.

Tables 1 and 2 indicate that if paradichlorobenzene is used it should be applied between September 15 and October 25. According to observations made during 1939 and 1940 peach borer moths were still in the field the first part of October. Therefore, if paradichlorobenzene is applied before September 15 it all may be dissipated before all the moths have completed egg laying or the eggs have hatched. Treatment should not be delayed after October 25 because the weather may be too cold for most effective results with paradichlorobenzene.

Ethylene dichloride emulsion seems to give generally better control than paradichlorobenzene when applied after September 25, or as soon as the moths have ceased laying eggs. It is necessary to wait until the moths have stopped laying eggs as the ethylene dichloride emulsion is dissipated more rapidly than the paradichlorobenzene. It is also deemed advisable to treat the peach trees as near October 1 to 15 as possible in order to lessen the damage caused by the borers.

NECESSITY OF MOUNDING WHEN USING ETHYLENE DICHLORIDE EMULSION.—If we examine Tables 1 and 2 and compare the treatments of ethylene dichloride emulsion that were mounded with those that were not mounded, it will be seen that the mounded treatments were better

[1] Research Contribution No. 18 published with the aid of the State College Research Fund, Department of Entomology, North Carolina State College of Agriculture and Engineering of the University of North Carolina.

[2] This material was furnished through the courtesy of the Taylor Chemical Co., Aberdeen, North Carolina.

than the treatments that were not mounded. The extra kill obtained by mounding is well worth the time and effort required in mounding.

SIZE OF MOUND AND NECESSITY OF TAMPING MOUND WITH THE BACK OF THE SHOVEL.—In order to check on the size of mound that is necessary and the necessity of tamping the mound, 7-year-old Elberta trees were treated with paradichlorobenzene and ethylene dichloride emulsion and mounded with 2, 4 and 8 shovels of sand. The mounds on 10 trees receiving each treatment were tamped down with the back of the shovel, whereas on ten other trees the sand in the mound was not tamped down.

Table 1.—Time of application and materials used.

DATES TREATED	PARADICHLOROBENZENE MOUND	MATERIALS USED ETHYLENE DICHLORIDE EMULSION MOUND	ETHYLENE DICHLORIDE EMULSION NO MOUND	CHECK
Sept. 15, 1939	31	31	131	133
Sept. 25, 1939	19	2	12	78
Oct. 5, 1939	13	3	10	85
Oct. 15, 1939	20	0	16	83
Oct. 25, 1939	17	3	8	77
Nov. 15, 1939	33	6	33	80
Feb. 16, 1940	82	5	89	146
March 16, 1940	25	18	41	148

These data indicate that the control obtained through the use of a large mound is not significantly greater than that obtained with a small mound. They also indicate that tamping the mound does not have any significant influence on the kill obtained with paradichlorobenzene or ethylene dichloride emulsion in sandy soil.

INJURY TO TREES.—Ten trees of each variety (1-year-old Sun High, 3- and 7-year-old Elberta and Halberta, 4-year-old Hales, 6-year-old Jubilee) were treated September 15, 25, October 5, 15, 25, November 15, February 16 and March 16, 1939. Of all the trees treated only two (Halbertas) showed slight injury. One was treated October 25, 1939 with *Scalecide* plus 15 per cent paradichlorobenzene diluted 1 to 7 and used at the rate of 1 quart per tree. The other tree (7 years old) was treated October 5 with 0.5 pint of 25 per cent ethylene dichloride emulsion. Both of these trees were heavily infested with borers at the time of treatment and the heavy feeding of the borers undoubtedly aided the chemicals in reaching the cambium in amounts sufficient to injure the tree. The injury was not fatal in either case even though the trees were practically girdled by the borers.

Some trees died in the plots in 1940, 1941 and 1942, but in most cases the major contributing factor was undoubtedly unfavorable climatic conditions as the injury occurred in treated and untreated plots. Also, in making a survey of orchards which had an unusual number of dying trees, it was found that injury occurred on trees that had always been treated with paradichlorobenzene, in orchards which switched to ethylene dichloride in 1939 and in orchards which switched to ethylene dichloride in 1940. Also, there were indications that the trees which died in 1941 and 1942 had been injured severely by unfavorable climatic conditions in the spring of 1940. A few of the trees injured in the spring of 1940 died the same year but a larger percentage died in 1941, and some lingered on until 1942. Many of the growers suspected ethylene dichloride of being the major factor in the death of the trees. Ethylene dichloride emulsion may cause injury to peach trees when it is not applied at the correct strength and dosage or where the bark has been severely damaged by some other agent. However, ethylene dichloride emulsion should not be judged guilty of killing the trees until we have some positive evidence. Thus far, the data obtained in North Carolina indicate that ethylene dichloride emulsion, when used at the correct concentration and dosage, is as safe to use on the peach trees as any other material known to the writer and known

Table 2.—Results of tests (1940-41) to determine best time to treat peach trees, value of mounding, and comparative value of paradichlorobenzene and ethylene dichloride emulsion. Numbers represent total number of borers found in 10, 8 year old trees in May, 1941.

DATES TREATED	PARADICHLOROBENZENE MOUND	ETHYLENE DICHLORIDE EMULSION MOUND	ETHYLENE DICHLORIDE EMULSION NO MOUND	CHECK
Sept. 10, 1940	1	27	79	98
Sept. 20, 1940	2	6	21	71
Sept. 30, 1940	1	0	8	126
Oct. 10, 1940	7	1	11	99
Oct. 20, 1940	2	4	18	151
Oct. 30, 1940	11	3	13	184
Nov. 10, 1940	29	0	20	104
Nov. 20, 1940	18	3	3	71
Dec. 15, 1940	30	0	12	78
Jan. 15, 1941	34	3	15	86
Feb. 15, 1941	31	1	21	135
March 15, 1941	45	18	35	56
April 3, 1941	60	8	23	136
April 15, 1941	8	16	20	186

Table 3.—Results of tests to determine size of mound and necessity of tamping the mound. Numbers represent total number of living borers found in 10 trees 7 months after treatment.

	Shovels of Sand	Treated Oct. 12, 1939		Treated Oct. 6, 1940		Treated Oct. 13, 1940	
		Tamp.	Not Tamp.	Tamp.	Not Tamp.	Tamp.	Not Tamp.
Paradichlorobenzene	2	21	12	2	3	8	8
	4	24	18	3	4	11	7
	8	20	9	2	2	6	4
Ethylene Dichloride Emulsion	2	5	6	2	1	1	5
	4	5	2	1	2	0	0
	8	7	3	1	3	0	0
Check	—	140	106	76	62	61	104

to be of value in controlling the peach tree borer.

EFFECTIVENESS OF ETHYLENE DICHLORIDE EMULSION DEMONSTRATED IN A COMMERCIAL ORCHARD.—Most of the writer's experiments (1939–1942) on the peach tree borer were conducted in various areas of a 225 acre block of trees, a different plot being used each year. All the trees except the writer's plots were treated uniformly in 1939 and 1940 with paradichlorobenzene and in 1941 with ethylene dichloride emulsion. The trees were 7 years old in 1939. This block of peach trees was bordered by other peach trees on 3 sides and by woods on the other side. This block of trees was chosen because there was a fairly uniform stand of trees and because of the heavy infestation of peach tree borers. The owner claims to have had the trees treated with paradichlorobenzene every fall since the trees were 3 years old. The writer checked on the workmen while they were putting out the paradichlorobenzene during October 1939 and it was his observation that the workmen were more careful and thorough than was usual in commercial orchards in North Carolina.

In checking the trees in the spring of 1940 it was found that the check or untreated trees averaged 10 to 12 borers per tree. These trees had been treated with paradichlorobenzene in the fall of 1938 but they were left untreated in 1939. In the spring of 1941 the check trees again averaged 10 to 12 borers per tree. These trees had been treated with paradichlorobenzene in the fall of 1939 but they were left untreated in 1940. In the spring of 1942 the check trees averaged 2 to 3 borers per tree. These trees had not been treated in 1941 but they and the rest of the orchard had been treated with ethylene dichloride emulsion in the fall of 1940.

The borer population of the checks is probably dependent on the moth population of the previous year and, therefore is, an indication of the efficiency of the treatment used in the orchard. Thus by using ethylene dichloride emulsion one season the initial surviving population of borers had been reduced from an average of 10 to 12 borers per tree to an average of 2 to 3 borers per tree. The above averages were obtained from approximately 100 trees in 1940 and 1941 and from 59 trees in 1942.

The writer also had small plots in a neighboring block in 1941–42 which had always been treated with paradichlorobenzene and the initial surviving population of borers remained high as it had been the previous years. This suggests that the ethylene dichloride emulsion is superior to paradichlorobenzene when put out by workmen in a commercial orchard.

SUMMARY.—Ethylene dichloride emulsion gave a more satisfactory control of the peach tree borer than did paradichlorobenzene.

Ethylene dichloride emulsion was used with equal effectiveness each year (1939–41) between September 25 and February 16. However, the writer believes it is advisable to treat between October 1 and 15 in North Carolina when using either ethylene dichloride or paradichlorobenzene.

It is definitely advantageous to mound peach trees when using ethylene dichloride emulsion but it is not necessary to pat down the mound in sandy soil.

A small mound is as efficient as a large mound.—10-19-42.

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A Destructive Apple Sawfly New to North America[1,2]

LOUIS PYENSON, *State Institute of Agriculture, Farmingdale, N. Y.*

Late in May 1939 the writer's interest was aroused by a mass of brick colored frass surrounding a hole in the young fruit of an ornamental crabapple tree. An examination of the fruit disclosed a sawfly larva hollowing out its center. This unusual sawfly injury was found a few days later on many varieties of ornamental crabapples and on a few wild apple trees. No damage was noticed in the Institute orchard.

Due to the inability of finding or rearing adults, the identity of this pest was delayed until May 1942 when adults were caught in a cage placed over the spot where infested apples had been put the previous June. These adults were identified by Dr. Herbert H. Ross of the Illinois State Natural History Survey as *Hoplocampa testudinea* Klug., a serious pest in Central Europe where it is recorded as being found in small apples prematurely dropped. This was the first record of this pest from North America that Dr. Ross had received.

Shortly after this new apple insect was announced in the June 8, 1942 *Weekly Newsletter* of the Extension Service, N. Y. State College of Agriculture, a further record of this pest was received from Dr. W. A. Ross, Chief of the Fruit Insect Investigations, Vineland, Ontario. "This insect is a pest of considerable importance in Europe, especially in Germany, France, Denmark, Holland, and parts of England; and it occurs in West Asia. In 1940 it was first reported from Victoria, B. C., but as it was found to be quite widely distributed in the city, it probably had been present for several years prior to that time. So far the infestation is confined to the Victoria District, Vancouver Island, where apple growing is of little commercial importance."

In 1941 injury was observed for the first time in the orchard in spite of the application of a regular spray schedule, and in 1942 extensive damage was again noticed. Applies brought in from Glen Cove in 1941 and from Wyandanch and Mineola in 1942 showed the characteristic sawfly injury. There is a possibility that this pest is much more widely distributed as Dr. P. J. Chapman of the N. Y. State Experiment Station stated in personal correspondence in 1939 that he found unidentified sawfly larvae boring in pears, and that Dr. Glasgow had noticed the same habit of a sawfly larva with apple and pear. The writer observed one case where this sawfly attacked a pear. Dr. H. H. Ross stated in correspondence that records seem to indicate that the entire genus *Hoplocampa* feeds within berries and fruits of the *Rosaceae*.

None of the 24 varieties of applies examined in the Institute's orchard appear immune to the attacks of this sawfly as infested drops were found under all of them. However, a preference for early blooming varieties was noted. The trees having the heaviest infestation in the orchard were the varieties Transcendant Crab and Dutchess of Oldenburg both early blooming; while the later blooming varieties were attacked to lesser degrees. The varieties of ornamental crabs heavily attacked were also of the early blooming type.

[1] Contribution from the Plant Protection Laboratory, State Institute of Agriculture, Farmingdale, L. I.
[2] Eastern Branch Program; New York, November, 1942.

LIFE HISTORY AND HABITS.—The adult sawfly (Fig. 1-A) is 7 to 8 mm. in length, colored yellow ventrally and shiny black dorsally. The head is yellow with yellow antennae and black eyes. A small black band extends forward from the vertex of the head over the ocelli. The wings are covered with tiny black hairs giving them a dusky appearance.

The sawflies began to emerge from the ground on May 4, 1942. At this time the earliest apple trees were just beginning partially exposed by removing the stamens and style of the blossom. Generally a single egg per apple was found, but occasionally two eggs were present in the same apple. Since some eggs had hatched 2 weeks after the first flies appeared, an incubation period of about a week is indicated.

The newly hatched larvae (Fig. 1-C) have black heads and black dorsal plates on the last abdominal segment. The rest of the body is white. The larvae feed briefly

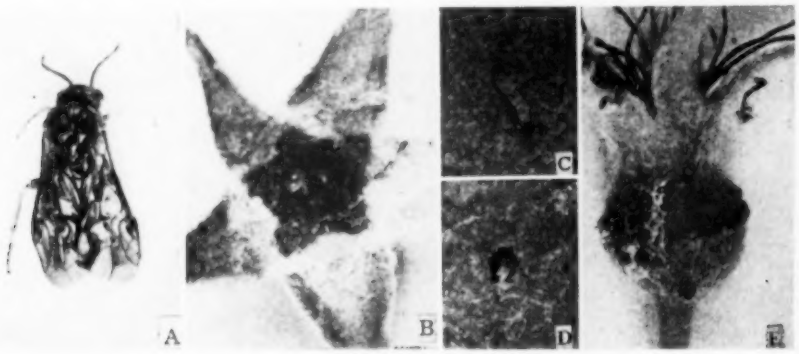

FIG. 1.—A, adult sawfly; B, egg deposited in calyx; C, newly hatched larva; D, larva entering apple; E, injury produced by young larva (magnified).

to blossom. The sawflies continued to emerge until May 12 when the trees were nearing the end of their blooming period. Twenty-six sawflies were caught in the cage over the spot where infested apples had been placed the previous June. Of these 26 sawflies, 16 were females and 10 males. Attempts to make observations of adults in cages failed as they became excited and died.

A few adults were also observed on blossoms on May 4 and continued to be seen for about two weeks, particularly on warm sunny days when their activity made capture difficult. The sawflies appeared to be most abundant near the tops of trees in heavy bloom, flying actively among the blossoms. Oviposition evidently started about a week after emergence, since a few hatched eggs as well as some with partly to fully grown embryos were found on May 18, two weeks after the first flies emerged.

The shiny, colorless, oval eggs are deposited with the aid of the ovipositor which pierces the base of the calyx at an angle and leaves an egg in the slit made on ts inner wall (Fig. 1-B). The egg may be within the calyx, then they either crawl out of the calyx and bore into the side of the apple (Fig. 1-D), or bore through the base of the calyx. In either case they continue tunneling under the skin of the apple for some length only to emerge to enter the same apple at another point or to enter a nearby apple and tunnel under its skin (Fig. 1-E). There is a heavy drop of unset or injured fruit at this time and many larvae undoubtedly perish in the drops since they are too sluggish to return to the tree. Some of the injured apples continue to grow and show characteristic markings (Fig. 3).

The larvae change their habits after what appears to be the first molt. Instead of boring under the skin they bore directly to the center of the apple and hollow it out (Fig. 2-A). This may occur in the original apple attacked, but more often in a new apple in the same cluster. The larvae in all instances appear to be able to bore readily into any outside part of the apple. After the second molt the larvae began to change in appearance. The head becomes yellow and the black posterior plates disappear. As the larvae grow they continue

to hollow out one apple after another, ejecting the characteristic brick colored frass from their tunnels (Fig. 2-B). The larvae seem to prefer to leave one apple for another in the early morning or on wet days when the fruit is damp, probably as a protection against desiccation. One larva during its life-time may destroy from 2 to 6 apples depending on their size and proximity to each other.

Larvae are full grown (Fig. 2-C) in about three weeks from date of hatching and average about 20 mm. in length. At this time they may leave the apple and descend to the ground or, which is more usual, they may drop with the apple and leave it later. A heavy June drop occurs under badly infested trees since all hollowed out apples drop to the ground. About 95 per cent of the large drops under trees on June 9 had larval holes in them and of these 13.8 per cent had full grown larvae in them. Another examination of the drops under the same trees made June 15 showed that 10 per cent were infested with larvae. Evidently many larvae do not leave the fallen apples at once. Larvae were found in new drops until June 19.

Larvae that had emerged from drops collected and placed over soil June 9 began the construction of pupal cases in the soil on the next day. When completed these pupal cases (Fig. 2-D) are mottled grayish black and average about 7.5 mm. in length and 3.6 mm. in width. The larvae do not burrow deeply into the soil before constructing cells as illustrated by placing 112 drops over 3 inches of soil. Of the 11 pupal cases found in the soil 4 were in the top inch and a half and 7 in the lower inch and a half. The larvae remain in the prepupal stage in these cells in the soil until early the next spring when they transform into pupae and begin emerging as adults when apple trees start to blossom.

DISCUSSION.—A consideration of the life history of this sawfly leaves little doubt that the pest was introduced in the pre-

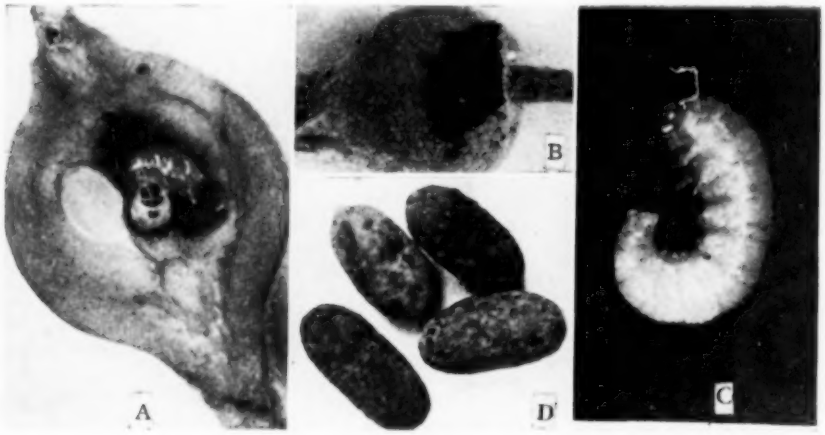

FIG. 2.—A, older larva hollowing out apple; B, frass produced by larva; C, full grown larva; D, pupal cases made by larvae (magnified).

pupal stage, probably in soil around the roots of ornamental crabs or other ornamentals. This possibility is substantiated by the fact that both places in North America where the pests were found are not apple growing regions but thickly settled areas where ornamentals abound. There is also some evidence that the pest was introduced at about the same time in the two infested areas on opposite sides of the continent as the writer first observed the pest in 1939 on Long Island and it was first identified in 1940 on Vancouver Island. In both cases it is very probable that the pest was present one or more years before its discovery. There is also little doubt that this pest finds seasonal conditions favorable and is well established in North America. Damage has increased considerably since the pest was discovered on the Institute campus in 1939. The original point of infestation on Long Island, judging from known areas where injury occurred, lies somewhere in the middle area of Long Island.

Although there is only one generation

a year the seriousness of this pest may be readily envisioned by noting that one larva may destroy several apples whereas other larval pests of apples usually remain in the fruit originally attacked. In some heavy producing varieties where thinning is necessary an infestation may not be too serious.

CONTROL POSSIBILITIES.—No special attempts to control this pest have been undertaken since its discovery, but observations were made on the effects of the regular spray schedule on its control. In this schedule the sprays of importance in controlling the sawfly are the calyx, curculio, and first cover sprays. These sprays containing the standard materials recommended for eastern New York appeared to be of little value in preventing infestation in the orchard. The most numerous fruit entries were made by larvae near the tops of the trees where spray coverage is usually the poorest. It appears doubtful whether the present orchard spray program is sufficient for good control of this insect. Apples sprayed with lead arsenate at the rate of 3 lbs. to 100 gals. of water proved toxic to young larvae, but evidently the thorough coverage that is necessary was not obtained in the orchard. Laboratory tests with 4 per cent derris powder (used 4 lbs. to 100 gals. water) against the young larvae were very promising as most of the larvae died on coming in contact with the sprayed apples without attempting to enter the fruit.

A supplementary aid to chemical control might consist of collecting and destroying the larger drops for a period of about 10 days beginning when the larvae reach full growth (about June 7).

SUMMARY.—The apple sawfly, *Hoplocampa testudinea*, Klug. was found on Long Island, N. Y. in 1939, and was identified on Vancouver Island, B. C., in 1940. Adult sawflies emerge from the soil during the blossoming period of apples, and lay their eggs in the calyx of the fruit. The larvae first burrow under the skin of the apple and, when older, hollow out the young fruit, excreting a brick-colored frass. Several apples may be destroyed by one larva. When full grown, usually during the early part of June, the larvae drop with the apples and enter the soil to construct pupal cases. They remain as prepupae in these cases until the next spring when they transform to pupae and finally to adults.

This pest was probably introduced and may spread to other areas in soil around the roots of plants. The standard calyx, curculio, and first cover sprays on apples do not appear to hold the pest in check.—12-2-42.

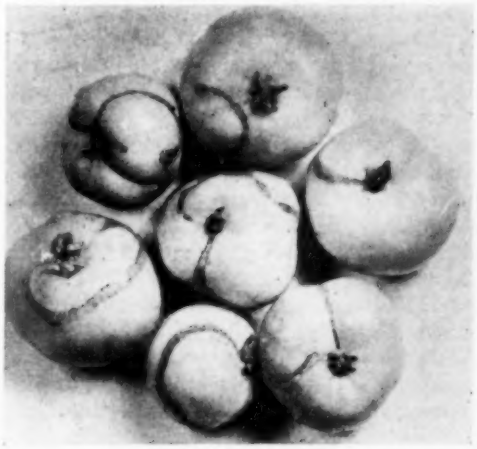

FIG. 3.—Characteristic sawfly injury on mature crabapples.

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ROBERT J. NORTON

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The Comstock Mealybug on Apples and Peaches in New Jersey[1,2]

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During November 1941, the writer received samples of apples from an orchard near South River in Middlesex County, and from an orchard near Matawan in Monmouth County. Both samples showed a heavy deposit of black sooty fungus growth on the upper surface and in the stem cavity of the apples. The Comstock mealybug was suspected as the cause of this condition. Later examination of the trees in early December revealed the presence of numerous egg masses under the bark and in crevices on the trunk and limbs. The eggs in these masses were yellow and covered with a white, waxy deposit characteristic of the Comstock mealybug which the writer had observed on several occasions in apple orchards in Virginia. Examination of adult females collected in these two orchards in the summer of 1942 showed definitely that the insect was the Comstock mealybug, *Pseudococcus comstocki* Kuw.

On August 26, 1942, the writer visited a peach and apple packing plant near Moorestown, Burlington County. Elberta peaches being run over the grader at that time showed masses of eggs in the stem end and black sooty fungus growth on the upper surface of the fruit. An estimated 50 per cent of the fruit was blemished in this manner. The brushing machine failed to remove either the black deposit or the egg masses deep in the stem cavity. Inquiry led the writer to the block of peaches from which the fruit had come and it was found that the trees were heavily infested with egg masses and migrating adults of a mealybug. This block of peaches adjoined an old block of Paragon apples which were also infested with mealybugs but not as heavily as were the peaches. Specimens from this orchard submitted to the Bureau of Entomology and Plant Quarantine were identified as *Pseudococcus comstocki* Kuw.

In addition to the three infestations reported above, egg masses and adults which resemble the Comstock mealybug have been collected in an old abandoned orchard near Glassboro, in Gloucester County, and in an orchard near Masonville, in Burlington County. From another orchard near Moorestown, in Burlington County, a single apple was sent in to the Entomology Department for examination and a single specimen of a mealybug believed to be *Pseudococcus comstocki* was found in the stem end cavity.

No systematic survey of orchards in New Jersey has been made to determine the extent of mealybug infestation. However, the foregoing account indicates that the insect is generally distributed and it is believed that additional orchards will be found where the insect is causing more or less damage.

RELATION OF INFESTATION TO TREE CONDITION.—According to Woodside (1936) and Schoene (1941) the Comstock mealybug has been a pest in commercial apple orchards in Virginia for the past 8 years. Schoene (1941) reported that mealybug damage in Virginia orchards was most severe in the high producing, well sprayed and fertilized orchards, particularly those which had received annual applications of nitrogenous fertilizer for a number of years. He also reported that mealybug injury had not been observed on unfertilized trees and very little injury had been observed on young bearing orchards. All the severely injured orchards were mature, ranging in age from 25 to 60 years.

So far, the observations made in New Jersey orchards appear to parallel those reported from Virginia. In the Monmouth County orchard severe damage was confined to three blocks of Ben Davis and one block of Paragon. The trees in these four blocks were approximately 40 years old. The three blocks of Ben Davis trees served as a windbreak for a series of greenhouses and had gone unpruned for years. The trees were also closely planted. The operator of this orchard said that the soil management practices he followed included liming every other year, cover cropping with peas in summer and rye in fall and winter. In the spring of 1939 a ton per acre of a 4–8–7 fertilizer was used, supplemented with from two to four

[1] Journal series paper of the New Jersey Agricultural Experiment Station, Rutgers University, Department of Entomology.
[2] Eastern Branch Program, New York, November, 1942.

pounds of cyanamid per tree. This was followed by the application of a 2–9–9 fertilizer (amount not stated) in the fall of 1940, supplemented by two to four pounds of cyanamid per tree in the spring of 1941.

The trees, when examined in December 1941, appeared to be in a vigorous growing condition, judging from the length and thickness of the terminal growth. The soil appeared to be deep, well drained, and well suited to the growing of apple trees. The soil management program followed by the grower had resulted in the trees becoming somewhat over-vegetative in the opinion of the writer. The operator reported that fully 50 per cent of the apples in these four blocks were off-grade due to the sooty fungus deposit, and on certain trees the percentage of damaged fruit was nearer 100 per cent. Blocks of young trees adjoining the old blocks showed some masses of overwintering eggs, particularly on the trees adjacent to the old trees, but the infestation was comparatively light. Fruit loss was comparatively light on these young trees according to the operator.

In the Middlesex County orchard, heavy deposits of overwintering mealybug eggs were observed in one block of trees but was limited to old Baldwin, Rome and Stayman trees approximately 45 years old. Trees 10 to 15 years old interplanted with the older trees showed comparatively few overwintering eggs. Other blocks of trees on this farm ranging from 10 to 25 years of age showed very little evidence of mealybug damage. No exact information on soil management practices was obtained from this orchard. However, it was observed that liberal mulching had been practiced and the cover crop was alfalfa. The stand and growth of the alfalfa indicated that the soil was in a high state of fertility and the growth made by the trees reflected this condition.

The block of peaches at Moorestown where severe damage to the fruit by *Pseudococcus comstocki* was observed in the late summer of 1942 is of special interest because this is the first time, so far as the writer is aware, that *P. comstocki* has been reported on peaches in damaging numbers. The block in question consisted of about 10 acres of Elberta trees approximately 25 years old. The peaches adjoined an old block of Paragon apples approximately 50 years old. Both the peaches and apples are planted on which appears to be a good peach and apple soil. At the time the writer visited the orchard on August 26, second brood migrating adult mealybug females were readily collected on the peaches and the rough bark was heavily infested with egg masses. That half of the peach block adjoining the old apple block was much more heavily infested than the other half, yet there was no apparent difference in tree growth between the peach trees bordering the apples and the peach trees farther removed. The peach trees, in spite of their age, appeared to be in excellent shape from the standpoint of growth. There was ample but not excessive twig growth, the foliage was dark green and there was a good set of large fruit on the trees. It appeared that the infestation had originated in the old apple block and had spread to the peaches.

Mealybugs were difficult to find on the old Paragon apple trees. Inquiry revealed that the block of apples had received no fertilizer or cultivation the past two seasons and had received only a partial spray schedule. It had been his plan to eliminate the block the year before but had failed to do so. For all practical purposes, the block had been abandoned and failure to cultivate and fertilize had resulted in short, stubby twig growth, just opposite from the conditions found in the orchards in Monmouth and Middlesex Counties. This "hardening off" of the tree growth presumably had resulted in a lessening of mealybug abundance as was observed by Schoene (1941) in Virginia apple orchards.

NUMBER OF GENERATIONS.—Schoene (1940) reported three broods of *Pseudococcus comstocki* on apples in Virginia. Observations indicated there were two and a partial third brood of the insect in central and southern New Jersey in 1942. The exact date of hatching of the overwintering eggs was not observed in any of the New Jersey orchards in 1942. However, first and second instar nymphs of the first brood were collected in the Monmouth County orchard on May 21. Migrating female adults of this brood were collected readily in the Monmouth and Middlesex County orchards on June 23 and 30. Mature females of the second brood were collected in these two orchards on August 28 and September 3 and in the peach orchard at Moorestown on August 26. Egg masses from this second brood

collected the last week in August hatched within a week in an outdoor insectary at Glassboro.

Mealybugs in various stages of development were collected in the peach orchard at Moorestown on October 15. On October 28 second and third instar and adult mealybugs were collected in the two apple orchards in Middlesex and Monmouth Counties.

RESULTS FROM PARASITE LIBERATIONS.—Through the cooperation of Dr. D. W. Clancy, in charge of the mealybug parasite laboratory of the Bureau of Entomology and Plant Quarantine at Charlottesville, Virginia, two parasites of *Pseudococcus comstocki*, which had originated in Japan and had been extensively colonized in Virginia, were made available for colonization in the two apple orchards in central New Jersey. Dr. Clancy supplied approximately 2000 mealybug mummies containing the parasite *Allotropa* sp. and 1000 mummies containing the parasite *Pseudaphycus* sp., together with the necessary cages for emergence of the adult parasites, for liberation on the first brood of mealybugs in the two apple orchards in Middlesex and Monmouth Counties. An additional 3000 *Allotropa* sp. mummies were supplied from the Virginia laboratory for liberation on the second brood of the mealybug in these two orchards.

In addition to supplying the parasite material, Dr. Clancy cooperated by receiving and rearing to maturity adult mealybugs collected in the two orchards by the writers. Records supplied by Dr. Clancy enabled the writers to report on the effect of the parasite liberations in terms of percentage of mealybugs parasitized.

The first shipments of *Allotropa* sp. and *Pseudaphycus* sp. parasitized mummies were placed in the two infested orchards on June 1 when it was estimated the majority of the first brood mealybugs were either in the second or third instars. Approximately 25 per cent of each species was allotted to the Smith orchard in Middlesex County and 75 per cent to the Becker Bros. orchards in Monmouth County. In the Monmouth County orchard the available material was divided into three approximately equal parts and placed in three different blocks which for convenience were designated "A," "B" and "D." In each block, in the Becker orchard, 25 mummies of *Allotropa* sp. in suitable emergence cages were attached to approximately every fourth tree. The same number of mummies of *Pseudaphycus* sp. were attached to every eighth tree in each block. In the Smith orchard the two species were distributed to every fifth and tenth tree.

The 3000 *Allotropa* sp. mummies supplied by Dr. Clancy for liberation on second brood mealybugs were placed in the two orchards on August 7. In liberating this second lot of parasites the same general plan was followed as was followed in the liberations on first brood.

To determine the result of the parasite liberations, adult migrating female mealybugs were collected from the first brood on June 23 and 30 and from the second brood on August 28 and September 3 in each of the blocks. In making the collections, from five to 10 mealybugs were collected from each tree in each block on which an emergence cage was located. The individual mealybugs were then placed in gelatin capsules and forwarded to the Charlottesville, Virginia laboratory for rearing. The percentage of mealybugs parasitized from the four blocks of trees in the two orchards are set forth in tables 1 and 2. Included in table 2 are the results from rearing a small number of second brood adult females collected from the apple and peach block at Moorestown in Burlington County.

The data in tables 1 and 2 show an exceptionally good establishment and build up of both *Allotropa* sp. and *Pseudaphycus* sp. Both species were recovered from each of the four blocks on first brood and second brood mealybugs. Since an examination of the emerged mummies placed in the orchards on first brood showed an estimated 4800 adult *Allotropa* sp. and 2200 *Pseudaphycus* sp. liberated in the four blocks, parasitization ranging from 10 to 28 per cent in the June 23 collection of first brood mealybugs appeared quite encouraging. The decline in parasitism recorded for the June 30 collection of first brood mealybugs apparently was due to the early emergence of parasites from the colonized mummies which resulted in the late maturing mealybugs largely escaping attack.

Second brood parasitization ranged from 10 to 55 per cent in the two series of collections in the four blocks. This repre-

sents an approximate five-fold increase from 6 per cent on first brood to 31.5 per cent on second brood. The bulk of the parasitism was made up of the two introduced species, however, the native parasite, *Clausenia* sp., was recovered from all blocks, running as high as 10 per cent in one block in the September 3 collection. Although only half as many *Pseudaphycus* sp. as *Allotropa* sp. were liberated on first brood, and no additional *Pseudaphycus* sp. were liberated on second brood, this species was twice as numerous as *Allotropa* sp. on both the first and second broods of mealybugs.

as much of a reduction as appeared to have taken place in the Becker Bros. orchards.

The writers are convinced that there was a marked reduction in the mealybug infestation in both orchards in 1942 as compared to 1941. Third brood mealybugs were difficult to find in all blocks the last of October, so much so that an attempt to collect third brood migrating adults to determine parasitization was abandoned in all blocks. Also the amount of overwintering egg masses under the bark, in crevices and around pruning scars was much less evident in all blocks at the close

Table 1.—Percentage parasitization of first brood *P. comstocki* in two apple orchards in Middlesex and Monmouth Counties following parasite liberations in 1942.

Orchard and Block	Date of Collections	Total Mealybugs Collected	Species Emerged		Total Parasitism Per Cent
			Allotropa sp. Per Cent	*Pseudaphycus* sp. Per Cent	
J. J. Smith	June 23	126	2.4	10.3	12.7
Becker Bros. "A"	June 23	56	3.6	23.2	28.6[1]
Becker Bros. "B"	June 23	66	3.0	10.6	13.6
Becker Bros. "D"	June 23	58	6.9	3.4	10.3
J. J. Smith	June 30	106	0.0	0.0	0.0
Becker Bros. "A"	June 30	157	0.0	0.0	0.0
Becker Bros. "B"	June 30	128	1.6	0.0	1.6
Becker Bros. "D"	June 30	134	1.5	0.0	1.5
Total and Averages		831	1.8	4.2	6.1

[1] One specimen of *Clausenia* sp., a native parasite, was reared from this lot of mealybugs.

As was to be expected, no *Pseudaphycus* sp. or *Allotropa* sp. were reared from the second brood adult mealybugs collected from the newly discovered infestation of *Pseudococcus comstocki* on apples and peaches in the Burlington County orchard. One specimen of *Clausenia* sp. was reared from second brood adults collected in this orchard, indicating that this native species is generally distributed.

MEALYBUG DAMAGE TO FRUIT IN 1942. —Mealybug damage to the fruit this past season was much less severe in both the Smith and Becker Bros. orchards than in 1941. The owner of the Becker Bros. orchard reported that loss from off-grade fruit resulting from the honeydew-sooty fungus deposit was negligible in 1942 whereas an estimated 50 per cent of the fruit from four blocks was rendered unsalable except as cider or pie apples in 1941. The operator of the Smith orchard also reported less fruit damage by mealybugs in 1942 as compared to 1941 but not of the 1942 season.

How much of the reduction was due to parasites and how much to weather and the change in growth condition of the trees as a result of the change in soil management, cannot be stated definitely. Based on the observations and experiences in Virginia of Schoene and associate, the senior writer suggested to the operators of both orchards that they cut down on the fertilizer used in previous years; that if any fertilizer was used that it be a complete fertilizer rather than one of high nitrogen content. The operator of the Becker Bros. blocks reported that no fertilizer of any kind was used in the fall of 1941 and that none was used throughout the growing season of 1942. Also no cover crops were planted in the fall of 1941 or the spring and summer of 1942. The soil management practices in the Smith orchard in 1942 were not learned, although it was observed that no additional mulch was added in 1942 and only a

minimum of cover crop and weed mowing was carried out in the block under study.

Different weather conditions encountered in central New Jersey in 1941 and 1942 may have affected the mealybug population. The late summer and fall of 1941 was very dry in central New Jersey, so much so that fruit failed to size up and color well, particularly winter varieties. The summer and fall of 1942 was just the opposite, with abundant moisture, so that fruit in general throughout the state grew larger than in a normal year. Schoene (1940) states: "Random observations indicate that wet weather washes off the honeydew and is unfavorable to the mealybug. . . . It is believed that soil moisture sufficient to produce succulent growth and a dry atmosphere are the conditions most favorable for mealybug development." It is believed that a deficiency of rainfall in the late summer and fall of 1941 favored mealybug infestation and damage in the New Jersey orchards and abundant rainfall during the same period in 1942 was unfavorable to the insect.

Table 2.—Percentage parasitization of second brood *P. comstocki* collected in apple and peach orchards in New Jersey in 1942.

Orchard and Block	Date of Collections	Total Mealybugs Collected	Species Emerged			Total Parasitism Per Cent
			Clausenia Per Cent	*Allotropa* Per Cent	*Pseudaphycus* Per Cent	
J. J. Smith	August 28	97	2.1	8.2	11.3	21.6
Becker Bros. "A"	August 28	86	3.5	12.8	25.6	41.9
Becker Bros. "B"	August 28	98	2.0	10.2	14.3	26.5
Becker Bros. "D"	August 28	99	0.0	6.1	4.0	10.1
J. J. Smith	Sept. 3	94	0.0	13.8	4.3	18.1
Becker Bros. "A"	Sept. 3	86	10.5	7.0	22.1	39.5
Becker Bros. "B"	Sept. 3	92	1.1	10.9	43.5	55.4
Becker Bros. "D"	Sept. 3	95	2.1	6.3	33.7	42.1
Totals and Averages		747	2.6	9.4	19.6	31.5
A. Collins apples	August 26	14	7.1	0.0	0.0	7.1
A. Collins peaches	August 26	48	0.0	0.0	0.0	0.0

Summary.—The presence of the Comstock mealybug, *Pseudococcus comstocki* Kuw., in damaging numbers was discovered in two apple orchards in central New Jersey in the fall of 1941. A third heavy infestation of this insect was discovered in a peach orchard in Burlington County in August 1942. In each of the three orchards severe mealybug damage was associated with old and vigorously growing trees, a relationship previously noted in Virginia. The liberation in 1942 of two introduced species of parasites on the first brood of mealybugs in the two apple orchards in central New Jersey resulted in the establishment of both species and a build up to a point where roughly one-third of the second brood mealybugs were parasitized. A marked reduction in damaged fruit resulting from mealybug activity was observed in these two orchards in 1942 as compared to 1941. The reduction in mealybug injury is believed to be due to a combination of parasite activity, unfavorable weather for mealybug build up in the late summer and fall of 1942 and a change in tree growth brought about by a change in soil management practices.—12-2-42.

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Sampling Studies on Orchard Spray Residues in the Pacific Northwest

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In investigations of spray residues in apple orchards, one of the major problems has been the determination of what constitutes an adequate sample. Fahey & Rusk (1939) made a study of sampling technic in orchards at Vincennes, Ind., with respect to variance within trees and between trees, but no statistical information is available on plot-to-plot variance within an orchard. Since the weather conditions, orchard practice, and methods of spraying in the Pacific Northwest are different from those in the Middle West, a statistical study of spray-residue variance was made in a representative Winesap apple orchard in the Yakima Valley during 1940, to determine the best practical sampling technic for use under these field conditions.

Methods.—The method of sampling was similar to that used by Fahey & Rusk (1939) at Vincennes, Ind. The entire apple was used for the recovery of residue, so that the residues could be studied from the time of the calyx spray until harvest. To avoid handling the residue before making the chemical analysis, each apple was collected by clipping the stem and allowing it to fall into a tared glass container.

The apples were collected from six trees, two located in each of three plots in different parts of an orchard. Three samples of five apples were taken at random from the top, middle, and bottom sections of each tree immediately before and after each of 6 cover sprays. The total number of samples was thus 648. Lead arsenate was used for all sprays.

The chemical analyses were made by stripping the residue from the fruit with sodium hydroxide and determining the arsenic content on a portion of the strip solution by the rapid volumetric method described by Cassil & Wichmann (1939). A series of 10 tests showed that this method of analysis yields results having a mean accuracy of 98.65 per cent and a standard deviation of 0.33 per cent.

Table 1.—Average spray deposits on six trees in three plots before and after spraying with lead arsenate.

	Deposit, in micrograms of As_2O_3 per square centimeter						
	Plot 1		Plot 2		Plot 3		
Spray	Tree 1	Tree 2	Tree 3	Tree 4	Tree 5	Tree 6	Mean
			Before spraying				
First	8.8	9.3	11.7	12.1	9.8	11.3	10.5
Second	11.2	9.4	10.2	13.9	13.3	11.9	11.7
Third	12.4	11.9	13.1	16.2	10.9	12.5	12.8
Fourth	13.9	15.0	15.4	17.2	18.7	14.5	15.8
Fifth	13.1	11.8	13.0	15.5	14.3	13.0	13.5
Sixth	14.8	11.8	14.3	14.8	14.9	13.5	14.0
Tree means	12.4	11.5	13.0	15.0	13.7	12.8	
Plot means	12.0		14.0		13.2		
General mean							13.0
			After spraying				
First	28.0	29.9	47.5	49.4	26.8	31.2	35.5
Second	22.8	28.9	25.1	32.1	24.6	22.5	26.0
Third	20.5	20.2	23.9	25.0	23.9	19.4	22.2
Fourth	28.2	28.7	26.9	30.4	30.8	29.5	29.1
Fifth	23.4	20.2	23.3	27.0	21.9	20.8	22.8
Sixth	24.8	22.8	24.8	22.4	25.2	20.2	23.4
Tree means	24.6	25.1	28.6	31.1	25.5	23.9	
Plot means	24.9		29.8		24.7		
General mean							26.5

RESULTS.—The results of these analyses, summarized by averaging the data for the 9 samples from each tree, have been arranged in table 1. The deposits from the top, middle, and bottom sections of the trees averaged 11.9, 13.3, and 14.0 micrograms per square centimeter before spraying and 24.9, 27.0, and 27.5 micrograms after spraying. The deposits before spraying reflect the effect of previous sprays, weathering, and fruit growth; whereas the deposits after spraying are larger by the amount added by the spray. The fluctuations of deposit are the natural result of an effort to maintain a sufficient protective deposit throughout the season.

Table 2.—Summary of analyses of variance of samples of spray deposit.

SOURCE OF VARIATION	DEGREES OF FREEDOM	MEAN SQUARE	
		Before Spraying	After Spraying
Plots	2	110.73	905.56[1]
Sections	2	125.03	204.82
Sprays	5	182.53[2]	1,404.81[1]
Interactions:			
Plot × section	4	21.94	104.21[1]
Plot × spray	10	8.66	333.66[2]
Section × spray	10	15.54[2]	44.78[1]
Plot × section × spray	20	5.79	14.93
Trees within plots	3	49.62[2]	79.48[1]
Interactions:			
Trees within plots × section	6	17.79[2]	11.62
Trees within plots × spray	15	13.30[2]	48.03[2]
Trees within plots × section × spray	30	4.38	14.31[1]
Samples within subclasses	216	3.35	26.64

[1] Significant (19:1).
[2] Highly significant (99:1).

ANALYSIS OF RESULTS.—The results were studied by the analysis of variance, the before-spray deposits in one analysis and the after-spray deposits in another. Since the same set of trees was used in each spray, and since the sections were the same in every case, interactions of tree and spray, section and spray, and tree and section can be separated. The variance among trees and interactions of trees can be separated into plot effects and tree-within-plot effects. A summary is shown in table 2.

In interpreting this analysis one should keep in mind that the estimate of error used to determine significance of each mean square must be a measure of random variation affecting the comparison in absence of any real difference.

There are three orders of sampling, namely, the primary 5-apple samples, trees within plots, and plots. Sections and sprays are fairly reproducible and may be thought of in this study as controllable factors. Since the sections are reproducible and taken the same way each time, the variance of samples within subclasses is an adequate measure of error for questions affecting trees. Differences among plots must be measured by differences among trees as error, while main questions based on plots as units must have an error term based on plots. Hence the variance of samples within subclasses is error for the four mean squares above it. The three interactions of trees within plots with sections, sprays, and sections × sprays, will be error terms for the three corresponding interactions involving plots. Trees within plots furnish error for plots. Plot × section is the fundamental error for section; plot × spray for spray; plot × section × spray for section × spray. If the interaction plot × spray is not significant, it is not essentially different from the interaction trees within plots × spray, and the two may well be pooled. The plot interaction, however, remains the basic error term when the plot is the test unit. The same reasoning also applies to other error terms.

DISCUSSION OF RESULTS.—It is seen that the estimates of variance are much lower before than after spraying. In some comparisons the coefficient of variation will be definitely lower. Results after spraying seem somewhat erratic, and many of the mean squares reflect the effect of the large residue on trees 3 and 4 following the first spray.

Differences between plots are not significant, after spraying. Even after spraying the difference seems to be due mostly to one plot and one spray. This is in line with other experience in this problem. Insect infestation and control usually differ more between plots than between adjacent trees, whereas spray deposits in adjacent trees may vary almost as much as in those well separated. Trees vary much more than do samples within trees. The sprays differ significantly, as might be expected.

Sections are not significantly different. Before spraying the interaction plot × section is not significant and might be pooled with trees within plots × section as error for sections, in which case sections would be recognized as differing significantly.

Both before and after spraying the variation among sections, though slight and barely significant, is in the expected direction. This finding is different from that noted in the Middle West. It is probably explained by rather uniform and moderate size in trees, lack of summer rain, and the general practice of heavier spraying in the Pacific Northwest.

After spraying the interaction plot × spray is very significant, the significance being due mostly to one plot and one spray. The interaction section × spray is significant, showing a differential relation of sections from spray to spray. Before spraying, trees within plots and all the connected interactions except the triple one are significant, the interactions showing a differential relation of trees within plots. After spraying, trees within plots and trees within plots × spray are significant, trees within plots × section is not, and the triple interaction shows a slight negative significance.

APPLICATION TO SAMPLING PROBLEM.—For sprays the three successive error terms corresponding to the three orders of sampling are plot × spray, trees within plots × spray, and samples within subclasses. While plot × spray is the fundamental error, it is contributed to by trees within plots × spray, which is in turn partly formed by samples within subclasses. The comparison of sprays in this problem applies to successive treatments on the same trees. Therefore, for general sampling and where similar treatments on different trees must be compared, the variation of plots, trees within plots, and samples within subclasses is a better guide. The variances for plots and trees within plots in table 2 cannot be used in this phase of the problem. The same plots and trees were used repeatedly, and these variances have a cumulative significance, which would not be expected in any one examination. The best variances to use are the average of plot-and-tree variances from separate statistical analyses of sprays. Samples within subclasses, on the other hand, are different each time, and the variance from the general analysis (Table 2) is usable.

The figures from before-spray determinations are studied by the methods of Snedecor (1940). Since the plots are not significantly more variable than trees within plots, these variances are pooled to give simply the variance between trees with 5 degrees of freedom. The six sprays are analyzed separately and given an average between-tree variance of 21.88.[1] Following Snedecor, $K \cdot A + B = 21.88$, $B = 3.35$, $K = 9$. A is solved as 2.06, A being the estimate of variance among samples caused by tree variation alone, over and above that expected from B, the within-tree variation. Variance of a treatment mean to be expected in material like this with N trees (and K samples per tree) is estimated as $A/N + B/NK$. The standard error can be estimated as the square root of this variance, as shown in table 3.

Table 3.—Expected standard error of the mean deposit for different numbers of samples per tree and different numbers of trees per treatment.

Number of Trees per Treatment	Standard Error, in Micrograms per Square Centimeter, for Indicated Number of Samples per Tree				
	1	3	5	9	12
1	2.33	1.78	1.65	1.56	1.53
2	1.64	1.26	1.17	1.10	1.08
4	1.16	.89	.82	.78	.76
6	.95	.73	.68	.63	.62
8	.82	.63	.58	.55	.54
12	.67	.51	.48	.45	.44

It will be seen at once that the error of the mean is reduced more by increasing the number of trees than by increasing the number of samples within trees. In practice several separate samples per tree will not be taken, but a composite of convenient size. A sample as large as 25 apples will be as easy to analyze as a smaller one, and the contribution of such a large sample, even though small, to the stability of the final result, may be utilized. A larger sample would be unwieldy. For the present it is not deemed desirable to merge samples from several trees. If this were done, the most efficient single sample from a treatment would consist of a few apples from each of many trees. Such combinations may ultimately be advisable for some determinations, but for the present in this laboratory trees are to be studied individually. Section representation may well be retained, since there are

[1] The same figure can also be derived by computing the variance of all trees (pooling plots and trees within plots) as 74.06; subtracting the variance for the pooled interaction of all trees and sprays, which is 11.44, dividing the remainder by 6, the number of sprays; and adding the variance 11.44 to this quotient. This is a statistical estimate of the real tree variance to be expected in sampling.

signs of a small difference. Hence it is proposed to sample as many trees as convenient, taking from each a 25-apple sample made representative as to sections but otherwise random. The expected standard error of a mean based on 1 tree is estimated as 1.65 micrograms per square centimeter (Table 3, 1 tree, 5 samples).

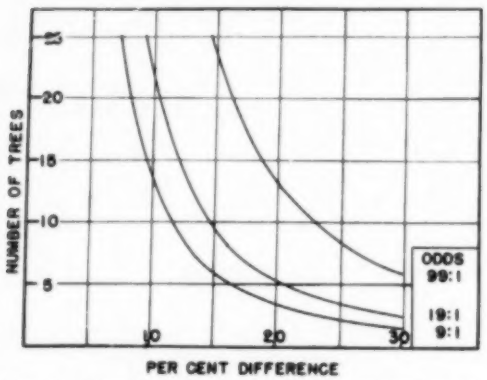

FIG. 1.—Number of trees sampled as related to accuracy, where a stratified sample of 25 apples is taken from each tree. (Before spraying.)

The coefficient of variation on a tree basis is thus 1.65:13.0 or 12.7 per cent. This is not exactly comparable with the coefficients discussed by Smith & Cassil (1937). Their coefficients were on a single-apple basis and would be expected to be 5 times as large as the within-tree part of our coefficient based on a 25-apple sample. On the other hand, our coefficient contains the larger between-tree variation.

Following Smith and Cassil's analysis, if D is a percentage difference of two treatments in terms of the common mean, Cv the coefficient of variation, and t the measure of significance for the level desired (Snedecor 1940, ch. 3), N is estimated as $2 \cdot (Cv)^2 \cdot t^2/D^2$. In this case t is used for 10, 5, and 1 per cent levels, for 5 degrees of freedom (number of tree units used in estimating standard deviation). A diagram similar to that used by Smith & Cassil has been worked out for the number of trees required to recognize differences of varying size (Fig. 1). The graph indicates that between 10 and 20 trees should be sampled in this way to recognize 15 or 10 per cent differences for odds of 19:1. Cochran (1938) has given us a useful discussion of the chance of missing a real difference, which will extend this line of thought.

The number of trees needed to show the desired significance can be diminished if the same trees are sampled throughout a given season. Since the data for before-spray deposits are used for this set of calculations, the resulting graph (Fig. 2) is strictly comparable with the one given in figure 1. Since interactions of plot × spray and trees within plots x spray do not differ significantly, they are pooled as interaction tree × spray. This variance is 11.44 with 25 degrees of freedom. Solving as before, A equals 0.90, and the expected variance among trees with 25 apples (or 5 samples) each is estimated as $0.90+3.35/5$, or 1.57; the standard deviation is 1.25, and the coefficient of variation is 9.6 per cent. Smith and Cassil's formula was used in constructing the graph in figure 2.

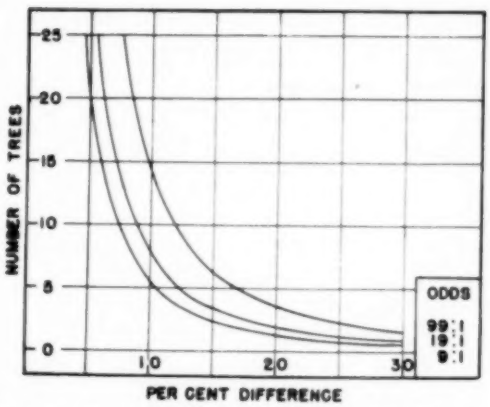

FIG. 2.—Number of trees sampled as related to accuracy, where a stratified sample of 25 apples is taken from each tree and the same trees are compared from time to time. (Before spraying.)

A similar treatment of after-spray data could be worked out. In this case the variance would be divided into three parts (as A, B, C) corresponding to plots, trees, and samples; since plots vary significantly more than trees. Equations would be

$$18A+9B+C = \text{plot variance}$$

$$9B+C = \text{tree-within-plot variance}$$

$$C = \text{sample variance}$$

However, because of the character of the variability and the small number of trees and plots, this analysis will not be carried out until more information is available.

SUMMARY AND CONCLUSIONS.—A study

has been made of sampling of residues from lead arsenate sprays in apple orchards of the Pacific Northwest, consideration being given to variation between plots, between trees within plots, between levels in the trees, between spray applications, and between samples within subclasses.

It is concluded that arsenic deposits measured after spraying are more variable than those measured before spraying, and are somewhat erratic in variation. Variation between sections of the tree barely reaches significance, but may well be allowed for in sampling. Trees within plots vary nearly as much as do plots; samples within trees are definitely less variable than trees. More gain in sampling precision will come from increasing the number of trees per treatment than the number of apples per tree. In future work in this laboratory, it is proposed to take from each tree a single sample of 25 apples representing all sections. For odds of 19:1 it is estimated that 10 to 20 trees taken at random will be needed to recognize 15 or 10 per cent differences, and when the same trees are sampled throughout a spray season 4 to 8 trees will suffice to show the same differences.—9-26-42.

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Effect of Lead Arsenate in Soil on Vegetables

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Larvae of the Japanese beetle, *Popillia japonica* Newm., have caused damage to garden vegetables, particularly when the crops were grown in the heavily infested area on land that had been in sod the previous season. As lead arsenate had been used successfully for several years to control these larvae in lawns and golf courses, some experiments of a preliminary, exploratory nature were conducted in 1933 and 1934 in the greenhouse and in the field at Moorestown, N. J., to obtain some information on the effect of adding lead arsenate to Sassafras sandy loam on the germination, seedling growth, and yield of several of the common garden vegetables and on the amount of arsenic assimilated in the edible portions of these vegetables.

The lead arsenate used in these experiments was purchased on the open market and was of the following composition: Arsenic oxide 32.41 per cent, arsenious oxide 0.28 per cent, water-soluble arsenic oxide 0.41 per cent, lead oxide 63.13 per cent, and moisture 0.14 per cent.

EFFECT ON GERMINATION.—Lead arsenate was thoroughly mixed with Sassafras sandy loam at rates equivalent to incorporating 1000, 1500, and 2000 pounds of the material with the upper 3 inches of an acre of soil. The soil containing these arsenical treatments and soil containing no arsenic were put in wooden trays, 18 inches square and 2.5 inches deep, and placed on the benches in the greenhouse. One tray of untreated soil and one tray of each of the arsenically treated soils were sown with 200 seeds of each of the vegetables. A daily record was made of the seeds developing in each tray.

The differences in germination in the untreated soil and in soil containing 1000, 1500, and 2000 pounds of lead arsenate per acre were very slight with asparagus, broccoli, brussels sprouts, cabbage, carrot, cauliflower, field corn, popcorn, sweet

[1] Deceased.

corn, cucumber, eggplant, endive, kohlrabi, lettuce, okra, onion, parsley, parsnip, pea, hot pepper, sweet pepper, pumpkin, radish, winter squash, tomato, turnip, and watermelon. The results indicated that the germination of these garden vegetables was not impaired when they were planted in soil treated with as much as 2000 pounds per acre of lead arsenate.

The germination of beets, muskmelon, and spinach in soil containing 1000 pounds of lead arsenate was 12 to 14 per cent less than in the untreated soil; and in soil containing 2000 pounds of the arsenical, the germination of these vegetables was reduced 13 to 22 per cent. There was a tendency for the percentage of germination of these vegetables to decrease with the increase in the amount of lead arsenate in the soil.

The lead arsenate was the most detrimental to the germination of lima beans and string beans. In soil containing 1000 pounds of lead arsenate per acre, the germination of lima beans was reduced 63 per cent and that of the string beans 28 per cent; in soil containing 2000 pounds of the arsenical, the germination of lima beans was reduced 98 per cent and that of the string beans 40 per cent.

EFFECT ON SEEDLING GROWTH.—Approximately 30 days after the vegetable seeds were sown in the trays, the seedlings were cut at the surface of the soil and measured.

The differences in seedling growth in untreated soil and in soil containing 1000, 1500, and 2000 pounds of lead arsenate were very slight with asparagus, onion, hot pepper, sweet pepper, pumpkin, spinach, tomato, and watermelon.

Of the other vegetables, the seedling growth of brussels sprouts, cauliflower, eggplant, endive, parsnip, pea, and winter squash was reduced less than 10 per cent in soil containing 1000 pounds of lead arsenate and 10 to 19 per cent in soil with 2000 pounds of the arsenical. The seedling growth of beets, cabbage, sweet corn, lettuce, muskmelon, parsley, radish, and turnip was reduced 10 to 19 per cent by the 1000-pound treatment and 11 to 37 per cent by the 2000-pound treatment. The growth of string beans, broccoli, carrot, field corn, popcorn, cucumber, kohlrabi, and okra was reduced 20 to 29 per cent in soil containing 1000 pounds of lead arsenate and 25 to 37 per cent in soil with 2000 pounds of the arsenical. The 1000-pound treatment was very detrimental to the seedling growth of lima beans, causing a reduction in growth of 87 per cent.

EFFECT ON YIELD.—In 1933, lead arsenate was applied in the field at the rates of 1000, 1500, and 2000 pounds per acre and thoroughly mixed with the upper 3 inches of soil. No fertilizer was used. In an untreated plot and in each of these treated plots, which were 20 feet wide and 180 feet long, were sown seeds of lima beans, string beans, beets, carrots, sweet corn, cucumber, lettuce, muskmelon, onions, parsnips, radish, and turnip; white seed potatoes were planted, and seedlings of cabbage, eggplant, hot peppers, sweet peppers, sweetpotatoes, and tomatoes were set out. The plots were kept in good tilth by frequent cultivation, and the insect pests were controlled as well as possible by hand picking and dusting with hydrated lime. In the treated plots, lima beans germinated but died. The first planting of string beans was a failure, but a satisfactory stand was obtained with the second planting. The early growth of all vegetables was retarded to some extent by the arsenical treatments, but after the roots had penetrated below the zone of arsenic contamination the plants appeared to develop normally. As the different vegetables matured, the crops were harvested and weighed. The results indicated that the incorporation of 1000, 1500, and 2000 pounds of lead arsenate per acre with the upper 3 inches of soil did not reduce the yields of these garden vegetables, with the possible exception of lima beans and onions.

In 1934, lead arsenate was applied again at the same rates to these plots and mixed with the upper 6 inches of soil. The plots then contained 2000, 3000, and 4000 pounds of lead arsenate per acre incorporated with the upper 6 inches of soil. It would be expected under these conditions that the possibility that a crop could draw nourishment from other than arsenic-contaminated soil would be largely eliminated. With the exception of hot peppers, the same crops were planted as in 1933, and in addition field corn and pumpkins were planted in each plot. The lima beans and the string beans did not grow in the treated plots, and turnips did not reach maturity. The yields of cabbage, carrots, field corn, sweet corn, cu-

cumber, lettuce, muskmelon, onions, parsnips, pumpkin, and radishes were reduced, but there seemed to be little difference in yield produced on treated and untreated plots with beets, eggplant, sweet peppers, sweetpotatoes, white potatoes, and tomatoes.

ASSIMILATION OF ARSENIC IN THE EDIBLE PORTION.—As the crops were harvested, they were carefully washed with water and wiped with a clean cloth. Representative samples of the edible portion of each crop were digested with nitric acid and sulphuric acid and the quantity of arsenic, expressed as arsenious oxide, in this portion of the plant was determined by means of the Gutzeit method. No arsenic was found in the vegetables from the untreated plot.

When 2000 pounds of lead arsenate per acre was incorporated with the upper 3 inches of soil, less than 0.005 grain of arsenious oxide was found per pound of fresh weight in the edible portion of string beans, beets, cabbage, sweet corn, cucumbers, eggplant, muskmelons, parsnips, hot peppers, sweet peppers, sweetpotatoes, white potatoes, and tomatoes; 0.005 to 0.01 grain per pound was found in carrots and onions, and 0.01 to 0.02 grain per pound was found in lettuce, radishes, and turnips. When 1000 pounds of the arsenical was mixed to this depth, only lettuce and radishes assimilated more than 0.01 grain.

When 4000 pounds of lead arsenate was incorporated with the upper 6 inches of soil so that plants had to draw a large share of their nourishment from the arsenic-contamined soil, less than 0.005 grain per pound was found in beets, cabbage, carrots, field corn, sweet corn, cucumber, eggplant, muskmelon, parsnips, sweet peppers, sweetpotatoes, white potatoes, and tomatoes; 0.015 grain was found per pound of lettuce, 0.029 grain per pound of radishes, and 0.060 grain per pound of onions. Of these vegetables only onions and radishes assimilated more than 0.019 grain per pound from the 2000-pound treatment applied to a depth of 6 inches.

No tolerance has been established for absorbed arsenic in vegetables, but the quantities found in the edible portions of these vegetables might be compared with the present tolerance on sprayed fruit.

SUMMARY.—The results of preliminary experiments indicate that the application of lead arsenate to soil reduced the germination of string beans and lima beans but did not seriously impair the germination of a number of garden vegetables, including asparagus, broccoli, carrots, cauliflower, corn, cucumbers, eggplant, okra, onions, parsnips, radishes, tomatoes, turnips, and watermelons. The results indicate that lead arsenate in the soil might be expected to retard the seedling growth of many of the vegetables. With the exception of beets, eggplant, peppers, sweetpotatoes, white potatoes, and tomatoes, a reduction in the yield might be expected with the garden vegetables grown on soil containing large quantities of lead arsenate. Little arsenic was found in the edible portion of most of the vegetables grown in soil treated with lead arsenate; the largest quantities were found in lettuce, onions, radishes, and turnips.—12-2-42.

Mass Production of the California Red Scale, and Its Parasite *Comperiella bifasciata*[1]

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Mass production of the red scale, *Aonidiella aurantii* (Mask.), and its parasite *Comperiella bifasciata* How. has been carried on for the past year at the University of California Citrus Experiment Station at Riverside, under the direction of Harry S. Smith.

The mass production of parasites of diaspine scale insects has been greatly facilitated by the discovery that squashes and other species of *Cucurbita* are suitable media for the growth and reproduction of the host insects. The first record of a *Cucurbita* sp. as a host of the red scale was made by Froggatt (1915), who stated that "pumpkins (squashes) left under infested trees became thickly covered" with the red scale. For the mass propagation of the red scale, squash was first used by the Orange County Insectary at Anaheim,

[1] Paper No. 483, University of California Citrus Experiment Station, Riverside, California.

California. Large numbers of the predator *Coccidophilus citricola* Brethes were reared on the red scale infesting the squash (Flanders 1936).

In 1937, banana squash was used in the insectary at the Citrus Experiment Station in the mass propagation of the red scale and its parasite *Habrolepis rouxi* Comp. This parasite had been introduced into California from Africa, where it occasionally attacks red scale on citrus.

In 1941, upon the introduction of a red-scale-feeding race of *Comperiella bifasciata* from China (Smith 1942), the mass production of the red scale in the insectary was greatly expanded. With an initial stock of five mated females of *Comperiella*, received the first week of May, 1941, a total production of over two million male and female parasites was attained by the end of July, 1942.[2] This production required the use of 4 tons of banana squashes. The number of parasites reared on one infested squash, over a period of three and one-half months ending November 1, 1941, totalled 6573.

The smooth-skinned banana squash, particularly the blue variety, is the most suitable for the mass production of the red scale. For insectary use each squash should weigh about 6 pounds. This is a size which is convenient for handling and which minimizes the loss of scale in case the squash breaks down as a result of disease. The period of usefulness of the squash is determined by its maturity and freedom from bruises. For this reason squashes should be carefully selected in the field and transported directly to the insectary.

Uncured squashes, that is, squashes used soon after harvesting, exude numerous droplets of liquid sugar subsequent to infestation with the red scale. These droplets harden when exposed to humidities of less than 55 per cent; at higher humidities they become fluid and interfere with the reproduction of the scale. Humidities above 55 per cent also favor the development of bacteria and fungi that cause the breakdown of the squash. When the propagation rooms are held at temperatures of about 80° F. and at 55 per cent humidity, the squashes support viable infestations of red scale for as long as four or five months.

[2] Refinements in the technique of mass propagation of the red scale were worked out by Glenn L. Finney, Superintendent of Insectary.

A small number of squashes may be set aside as "mother fruits" to serve as a source of young scale for purposes of infestation. Citrus fruit, particularly grapefruit, is more efficient than squash as a mother fruit for the production of scale crawlers, four heavily infested grapefruits providing enough crawlers to infest one 6-pound squash per day. Grapefruit, however, must be kept at humidities between 80 and 85 per cent in order to prevent shrinking. Coating about one third of the fruit at the stem end with paraffin retards this shrinking.

When a squash is to be infested, the young crawlers are transferred to it by brushing them off the mother fruit with a soft camel's-hair brush. Within an hour the crawlers "settle down" and begin the construction of the "white caps" of wax. After settling, the red scale develops through three instars, or stages. The developmental period, at temperatures about 80° F., is accordingly divided into three periods of 10, 10, and 18 days, respectively. The construction of the scale covering occurs during the first half of each period.

In the production rooms in the insectary, the squashes are placed on a series of shelves opposite a glass window, the number and length of the shelves depending upon the height and width of the window. The shelves are wide enough to accommodate four rows of squashes and are spaced so that there may be approximately 2 inches between the fruit and the shelf above. The bottom shelf is several inches wider than those above and extends to meet the base of the window. The shelves are supported on a framework mounted on rollers, so that they can be moved as a unit.

When the initial infestation of scale is about 20 days old, each infested squash is supplied with about 25 mated females of *Comperiella*. This is a sufficient number of parasites to sting the scales on any one squash. The use of a larger number of females increases the danger of destroying the scales by overstinging. Parasite reproduction occurs continuously, as long as the squash is suitable for scale development. It usually reaches its peak, however, about two months after it commences.

Since the males of *Comperiella* are more strongly attracted to positions of high light intensities than are the females, it may be necessary to suspend a white cloth

over the outside of the window, in order to diffuse the light and thus prevent a marked segregation of the sexes. Cloth over the inside of the window impedes the movement of *Comperiella* and consequently cuts down production.

In order to obtain maximum reproduction, it is necessary to provide food for the ovipositing females each day. This is done by placing hairline streaks of pure honey on the squashes and on the glass near the top of the window, where the parasites congregate. A humidity of 55 per cent keeps the honey sufficiently fluid for the feeding of the parasites, but not so dilute that bacteria and mold can develop upon it.

When it is necessary to replace a nonproductive squash, the new squash is placed next to the window, so that the scale is more exposed to attack by parasites emerging from scale on the older infestations.

Although *Comperiella* prefers to oviposit in the younger stages of the red scale, and solitary female parasites attain their maximum number of progeny in such stages, it is advisable to use older scale under insectary conditions when adult parasites are numerous. The use of older scale reduces the danger of overstinging and also results in more rapid increase in parasites, since the life cycle of *Comperiella* is shortest in such scale.

The collection of adult *Comperiella* is facilitated by their habit of congregating on the window at its upper edge. The migration of the adults to the window occurs for the most part in the middle of the afternoon. The parasites are collected from the window into glass vials by means of an aspirator. In order to do this conveniently, the production unit is moved back from the window to provide a working space for the collector. The parasites may be kept in the glass vials for several days if provided with sufficient food and placed in a cool, dark place.

For the efficient production of *Comperiella*, it is necessary to keep the insectary free from such scale enemies as the golden chalcid, *Aphytis chrysomphali* (Mercet), and the coccinellid *Lindorus lophanthae* (Blaisd.). Both of these insects are likely to be present in field-collected material.

The squashes sometimes become infested with the Pacific mite, *Tetranchus pacificus* McG.; and the grapefruits, with the citrus red mite, *Paratetranychus citri* (McG.). The webbing formed by these mites may interfere greatly with parasite reproduction. Satisfactory biological control of these mites has been obtained in the insectary at the Citrus Experiment Station by the use of the predatory thrips *Scolothrips sexmaculatus* Perg. When the squashes become thoroughly coated with webbing, heavy infestations of mites die out completely. The webbing forms an impassable barrier to the mites and cuts them off from their food supply. Under such conditions the surface of the squashes takes on a glossy appearance.

SUMMARY.—Squashes (*Cucurbita* sp.) are suitable media for the mass production of diaspine scale insects. In the insectary of the University of California Citrus Experiment Station, over two million specimens of the parasite *Comperiella bifasciata* How. were produced from the red scale, *Aonidiella aurantii* (Mask.), grown on banana squash, during the year ending July 31, 1942.

The technique of producing the red scale and its parasite is described.—11-14-42.

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The Pine Sawfly *Neodiprion sertifer* Geoff. and Its Control with Concentrated Lead Arsenate Sprays[1,2]

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Several different species of sawfly larvae have been injurious to pines in New Jersey for a number of years. Few of these species have become epidemic and caused serious, continued injury to their host plants. However, in 1937 a European species, *Neodiprion sertifer* Geoff, was found doing considerable injury to pine plantings in central New Jersey. This species was first collected in the larval stage, but not recognized as a new species, in Somerset County in 1925 and 1926 during the gipsy moth survey work. Since 1937 it has become increasingly abundant and has caused extensive defoliation of several species of pine planted for timber and for watershed protection. It threatens to become a serious pest and control measures applicable to forest, watershed and nursery plantings are needed.

At the beginning of the work reported in this paper it was recognized that the larval stages are easily killed with arsenical poisons or sprays or dusts containing rotenone or pyrethrins. Also that they could be controlled by concentrated lead arsenate sprays applied by autogiro or aeroplane. Autogiros and aeroplanes are often difficult to obtain, particularly for small plantings, and during the present war emergency are not available. The work reported here concerns principally the application of concentrated lead arsenate sprays applied with high pressure sprayers as described later.

SYNONYMY.—This pine sawfly is an European species and was first described under the generic name of *Laphyrus* Latr. later replaced by *Diprion* Schr. It is generally known in the United States under the name of *Neodiprion sertifer* Geoff.

DISTRIBUTION.—*Neodiprion* (*Diprion*) *sertifer* has been found in Sweden, Finland, Russia, Germany, Austria, Hungary, Czechoslovakia, and Japan.

In the United States it was first reported from New Jersey and has been recorded from Michigan and Ohio. Undoubtedly it is much more widely distributed since taxus plants from the infested regions have been shipped throughout many of the eastern states. In its early records it was found only in woodland and nursery plantings but in 1941 it was reported a number of times from ornamental plantings of pines, particularly mugho pine.

HOST PLANTS.—In the United States, observations indicate that the favored food plants are red pine, *Pinus resinosa*, Scotch pine, *P. sylvestris*, Japanese red pine, *P. densiflora*, Jack pine, *P. banksiana*, Swiss mountain pine, *P. montana*, and mugho pine, *P. montana mughus*. Light feeding has been observed on white pine, *P. strobus* and Austrian pine, *P. austriaca*, growing in close proximity to pines more favored as food plants. The damage has been most extensive on forest plantings of red pine and Scotch pine and ornamental plantings of mugho pine. The red pine and Scotch pine are the most severely injured in forest plantings, while mugho pine is the most seriously injured in ornamental plantings.

DESCRIPTION.—The adults are from 7 to 9 mm. in length and have rather stout bodies, particularly the females. In the males the antennae are feathery, the head and thorax black, the abdomen more or less blackish above and reddish-brown beneath, and the legs reddish-brown. The females are yellowish brown, with the antennae, except the basal segments, the eyes and metathorax blackish.

The eggs just before hatching are whitish, about 2 millimeters in length, and are elongate oval in shape. They are laid in rows in slits in the pine needles (Fig. 1).

The full grown larvae (Fig. 2) are about 22 millimeters long. They are a dirty grayish-green color, with a longitudinal dorsal line of a lighter shade. Laterally there are two whitish lines bordering a stripe of very intense green or sometimes blackish which has a tendency to break up into spots. The head, thoracic legs, and the dorsum of the anal segment are black. Arising from the dorsal and pleural areas are many short black setae, those on the

[1] Journal series paper of the New Jersey Agricultural Experiment Station, Rutgers University, Department of Entomology.
[2] Eastern Branch Program, New York, November, 1942.

dorsum being arranged in transverse rows.

The cocoons are light to dark golden brown in color, of a fine texture though tough, and are 8 to 10 millimeters in length with rounded ends.

LIFE HISTORY AND HABITS.—The adults emerge from their cocoons in September. The females lay their eggs in rows in slits on the pine needles of the current year's growth. The number of eggs in a row varies from several to more than 10, and there may be 200 or more eggs in the needles of a single terminal growth. The winter is passed in the egg stage, as is common with a number of sawflies. The eggs can withstand fairly low temperatures. In Germany it has been said that they survive at temperatures as low as −22° F. The eggs hatch in late April or early May or about the time the terminal buds begin to grow.

FIG. 1.—Eggs of *Neodiprion sertifer* in red pine needles. About half-size.

The young larvae feed at first on the side of the old needles, where the eggs were laid, and when abundant their feeding causes a distinct browning or scorched appearance of the needles at the tip of the twig. The larvae are gregarious, and a single terminal may have several hundred individuals feeding upon it. After the first moult the larvae eat the entire needle. By the time the larvae are one-half grown they have consumed considerable foliage and may have migrated to new uninfested terminals. Their injury is shown in figure 3. The new growth developing in the spring is not fed upon unless the larvae are virtually starved. The larval stage may last from 4 to 5 weeks.

FIG. 2.—Pine sawfly larvae. Slightly enlarged.

Most of the mature larvae drop or crawl to the ground where they spin their golden brown cocoons in the duff or litter on top of the soil. A few of the larvae may spin their cocoons in protected places on the trunk or branches. In one infestation where the pine webworm, *Acantholyda erythrocephala* L., also occurred, and had left considerable webbed frass on the twigs, the cocoons of *Neodiprion sertifer* were common in this webbed frass. The larvae pass the summer in the cocoons, pupate in late August or early September, emerge, and lay their eggs. There is only one brood a year.

Parasites.—*Neodiprion* is an established European species and sometimes causes considerable damage to forest plantings of pine. Many European references refer to its parasitic and predaceous enemies. The eggs, larval, and cocoon stages are attacked by various species of Hymenoptera, Diptera, and predaceous bugs.

The New Jersey State Department of Agriculture is rearing and releasing the parasite *Microplecton fuscipennis* which infests the sawfly in the cocoon stage.

Control.—Pine sawfly larvae of the genera *Diprion* and *Neodiprion* are easily killed by various stomach poison and con-

FIG. 3.—Larvae of *Neodiprion sertifer* and injury to red pine. About half-size.

tact poison insecticides. The tests reported herein were made not to determine what insecticides would kill the larvae but to ascertain whether concentrated sprays of lead arsenate applied to woodland plantings with a power sprayer would give an economical control.

Concentrated mixtures of lead arsenate sprays have been successfully applied by autogiros and aeroplanes for the control of leaf eating insects in woodland areas. Autogiros or aeroplanes are not often available, however, and are not practical for small isolated areas.

Spraying with the usual concentrations of lead arsenate that is 3 or 4 pounds to 100 gallons of water, where each individual tree must be sprayed, requires several hundred gallons of spray per acre and considerable labor and time to apply it. In this work the concentrated spray was not applied directly to the trees but rather it was directed up between or over the trees and allowed to spread by drifting, as shown in figure 4.

After some preliminary tests the formula finally used in 1941 was as follows: 48 pounds of Sherwin-Williams dry dispersed lead arsenate, 300 gallons of water, one gallon of Sherwin-Williams *Spralastic* (a quick breaking oil sticker) and one pint of *Grasselli Spreader and Sticker*, manufactured by E. I. du Pont de Nemours and Company Inc. This gave a concentration of approximately one pound of lead arsenate to 6 gallons of water. The lead arsenate did not adhere as well as might be desired but as there were no rains during the tests it was not washed off.

The formula used in 1942 consisted of 48 pounds of lead arsenate, 3 gallons of a quick breaking emulsified fish oil spreader and 300 gallons of water.

The spray was applied in 1941 with a Bean sprayer with a capacity of 35 gal-

FIG. 4.—Method of applying spray to control the pine sawfly larvae.

lons per minute at 700 pounds pressure and in 1942 with another Bean sprayer having a capacity of 65 gallons per minute at 700 pounds pressure. A pressure of 700 pounds was maintained at the spray pump. From 400 to 500 feet of one-half inch high pressure spray hose was dragged out through the plot to be sprayed. In 1941 a short Bean park spray gun with a shut off and a disk opening about 0.1 inch was used. A shade tree gun, without a shut off and an opening of about 0.25 inch was used in 1942. The spray from the gun was directed up into the air between the trees, the spray gun being moved around in different directions. An area from 50 to 75 feet wide could be satisfactorily covered in this manner. The spraying was started at the fartherest distance from the sprayer and the hose dragged back to the sprayer making applications through the trees every 50 to 75 feet or as often as necessary to give some overlapping of the drifting spray. The spray broke up well and drifted down through the trees giving good coverage. Where the foliage was dense there was little lead arsenate deposited on the inside of the trees. However, the infestation of the sawfly larvae under such conditions was always on the outside portions of the trees and adequate coverage by the spray was obtained on the infested portions. The spray hose was dragged through the pine plantings at intervals of 125 to 150 feet.

Most of the spraying was done at the New Jersey State Sanatorium for Tuberculosis Patients at Glen Gardner. Some of the pine plantings are solid plantings of either red or Scotch pine and are about 17 years old, 6 to 10 inches in diameter and 25 to 30 feet tall. Other plantings vary from 6 to 8 years old, consist of red, Scotch and white pine and are from 10 to 15 feet tall. The plantings around various buildings vary in age and size.

SPRAYING IN 1941.—The spraying in 1941 consisted of four plots containing approximately 25 acres. Four blocks of larger trees containing 10.7 acres were sprayed May 13. An average of 120 gallons of spray per acre was applied at a cost of $7.00 per acre. On May 14 approximately 1000 gallons of spray were used in spraying 14.5 acres of smaller and mixed sized trees. Eight hours of spraying were required. The total cost for materials, rent of sprayer and labor was $65.00. This gives an average of approximately 70 gallons of spray per acre at a cost of $4.80.

Examinations of the sprayed trees made a week after spraying and at later dates throughout the spring and summer showed that there was essentially complete kill except in a few small spots which had not been covered by the drifting spray. The distribution of the lead arsenate particles upon the pine needles was exceptionally good, and a good kill of the larvae was obtained even on areas which showed almost no lead arsenate on the needles. In one block where the trees were planted 4 by 6 feet the foliage was very dense and the spray did not drift down through the branches. However, the outer branches were covered and since the larvae feed only on the outer and exposed twigs a good kill was obtained.

INFESTATION IN 1942.—The eggs began to hatch about April 20 in 1942 and by May 1 the larvae were 0.25 inch long. A thorough examination at this time showed almost no infestation in the 4 plots of larger trees, a light infestation in the mixed area around and a considerable increase in the infestation throughout the entire area of smaller trees. Even though almost 100 per cent kill of the larvae had been obtained in that portion of the area sprayed in May 1941 the reinfestation from the unsprayed areas had resulted in an increase in the number of infested twigs. The two unshaded areas to the right consisting of mixed plantings of spruce and pine were also infested in 1942. The adult females are fairly strong fliers and spread out over a considerable area. This is also indicated by the fact that ornamental plantings of mugho pine in New Brunswick and Highland Park quite frequently showed larvae of *Neodiprion sertifer* even though there were no known infestations within a number of miles.

SPRAYING IN 1942.—The results of the spraying in 1941 showed that an excellent kill of the larvae could be obtained with a concentrated lead arsenate spray at a reasonable cost but that it would be necessary to spray the entire area to prevent serious and rapid reinfestation.

All the areas were sprayed in 1942 with the concentrated lead arsenate spray with emulsified fish oil sticker. An area consisting of 6.4 acres was used for pasture and was sprayed with a contact insecticide and another area, of 4.3 acres, was not

sprayed because it was so grown up with underbrush that the sprayer could not be gotten through the plot. The spraying was done May 11, 12, 13 and 14.

Data on the spraying in 1942 is as follows:

Total area sprayed	68.6 acres
Spray material used	6700 gallons
Gallons spray per acre	97+
Lead arsenate used	1080 pounds
Cost at 13 cents per pound	$140.40
50 gallons Sherwin-Williams *Sticker No. 2* at 75 cents per gallon	$37.50
24 Hours spraying at $5.50 per hour	$132.00
Estimated cost of labor for dragging hose	$41.00
Total cost of materials, labor and sprayer	$350.90
Cost per acre	$5.10

Although the amount of spray per acre averaged about 100 gallons, it varied from approximately 60 gallons for an area of 4.7 acres of small trees, to approximately 125 gallons per acre for some trees, which were the largest and most difficult to spray.

The sprayed areas were examined May 21st and 22nd. The kill was very good wherever the spray had been applied to the trees. A few trees were found in spots which had evidently been missed in the spraying. The sawfly larvae were almost full grown and in some cases the feeding was so heavy that the foliage was more than half gone. The control, however, was very good wherever coverage had been obtained. Examinations made in late October, after the adults had emerged and laid their eggs in September, showed very few eggs even in an unsprayed area of 4.3 acres.

SUMMARY AND CONCLUSIONS.—The pine sawfly, *Neodiprion sertifer*, is a serious pest of forest plantings of red and Scotch pines and unless controlled may cause extensive damage.

Sprayings during two summers have shown that the sawfly larvae may be readily and economically controlled by concentrated sprays of lead arsenate applied by high pressure with a ground sprayer. The spray is not applied directly to the trees but is directed up through, or over, them and drifts down from above. The best time to apply the spray is when the larvae are 0.25 to 0.4 inch in length or during the latter part of April or in early May.

Approximately 100 gallons of the concentrated spray were required per acre for trees averaging 10 to 15 feet tall and planted 6×8 feet.

The cost of spraying including rent of sprayer, materials and labor varied from $5.00 to $7.00 per acre.—12-2-42.

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The Colorado State quarantines relating to the European corn borer and the Oriental fruit moth were revised effective April 1, 1943, to extend the regulated areas to include additional territory. Host fruits of the moth are now embargoed as to entry into Colorado in line with current quarantines of other western States, and nursery stock continues to be admitted under standard conditions and limitations.

The Governor of Montana established a quarantine pertaining to the Oriental fruit moth, effective February 1, 1943, similar to such quarantines of other western States, and revoked the order pertaining to tomato pinworm effective March 17, 1943. This is the fourth State to lift its quarantine order pertaining to the pest.

Relation of Composition to the Efficiency of Foliage or Summer Type Petroleum Fractions[1,2,3]

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A series of petroleum oils[4] having a viscosity range of from 54 to 80 seconds Saybolt at 100° F. were tested during the past three seasons to determine their efficiency in killing eggs of the oriental fruit moth, the codling moth, and the eye-spotted bud moth, *Spilonota ocellana* (D & S). The oils were made into emulsions and applied to the eggs in the form of spray, using a standard-type power orchard spraying machine. The products tested are fairly representative of the various types of "summer" oils which have been used within recent years to treat deciduous trees in foliage. They were manufactured from both paraffinic and napththenic crudes by the principal types of refining methods; that is conventional refining, solvent processing and heavy acid treating.

Just what constitutes a summer, foliage or verdant type spray oil—as they are variously termed—is not very clear. The more frequently used criteria in current specifications of such products are the properties of viscosity, unsulfonated residue and distillation range. Data of this nature are useful, but as we have pointed out in our studies of dormant spray oils (Pearce *et al.* 1942), they give only a limited amount of information on the chemical composition of a product. The present article is an introductory report of the relationship found between insecticidal efficiency and the composition of summer oils. It is similar in scope and treatment to our report published on dormant oils (Pearce *et al.* 1942).

A consideration of the phytotoxic characteristics of an oil is a highly important phase of any research program on spray oils, particularly of summer spray oils. We hope later to be able to submit one or more reports of our work on this subject, but in the present paper we have confined ourselves to findings on insecticidal efficiency.

Biological and Methods.—Details of the conditions existing and methods followed in conducting the tests reported here have varied considerably. The procedure most commonly used, follows: Moths of each species were induced to deposit their eggs on leaves of potted two-year-old Rhode Island Greening apple trees and, in some tests, on potted quince trees. A sleeve cage ten to twelve inches long, constructed of window screening, was placed over a single terminal. The confined insects were thus allowed to deposit their eggs on approximately 15 leaves. Caged terminals were exposed to oviposition for 72 hours in the case of the codling moth and bud moth. Because the incubation period of oriental fruit moth eggs is short, cages containing this species were in place only 48 hours. A greenhouse was employed as an oviposition chamber. Its use permitted a greater degree of standardization of conditions than would have been possible outdoors. Usually, eggs of two species were used in each test, moths of each species being caged on separate terminals of the same tree. In one series, eggs of three species were pres-

Table 1.—The number of eggs used per test and their distribution on the leaves, 1941 and 1942.

Species	Number Tests	Average Number Eggs per Test	Percentage Eggs on Upper leaf surface	Percentage Eggs on Lower leaf surface
		Quince		
Bud moth	24	304	82.3	17.7
Codling moth	7	208	86.2	13.8
Oriental fruit moth	47	615	78.2	21.8
		Apple		
Codling moth	142	242	58.0	42.0
Oriental fruit moth	144	675	66.4	33.6

[1] This is Paper No. V in a series appearing originally under the general title "The use of petroleum oils as insecticides."

[2] Journal paper No. 536. New York State Agricultural Experiment Station, Geneva, New York, Nov. 23, 1942.

[3] Presented at the Eastern Branch Program and Awarded the Annual Medal of the Eastern Branch of the American Association of Economic Entomologists for the year 1942.

[4] Supplied by the following manufacturers: Socony-Vacuum Oil Co., United Refining Co., Sun Oil Co., L. Sonneborn Sons Inc., California Spray Chemical Co., Shell Oil Co., and Standard Oil Co. of New Jersey.

ent on each tree. Among other advantages, this technique permits the more certain detection of any specificity in the response of eggs to the treatment should this exist.

The number of eggs involved per test and their disposition on the leaves is given in table 1. A small percentage of eggs were infertile, or in any event, consistently failed to hatch in control lots. With the oriental fruit moth controls, mortality has never exceeded 4 per cent. Occasionally a higher mortality was obtained in the case of the codling moth but variations of this nature with any of the three species are not believed to have affected the results reported in any but a very minor way. No correction for this natural mortality has been made in efficiency computations.

The oils were emulsified in the spraying machine immediately before application. A description of the equipment and the procedure followed in emulsification have been given in an earlier paper (Chapman *et al.* 1941). Exceptions to be made to this statement for the present tests are that spray was delivered from the spray-gun at the rate of 5 gallons per minute, a pump pressure of 400 pounds was maintained, and test lots were made up in 25 as well as in 50-gallon batches.

Although a number of emulsifying agents and also some commercial oil spray stocks were investigated, only the tests in which blood albumin was the emulsifier are included in the present report. The product used was a mixture of 1 part albumin by weight, and 3 parts diatomaceous earth. This was used at the rate of 8 ounces of the mixture (2 ounces actual blood albumin) per 100 gallons finished spray mixture.

All of the spraying was done outdoors. For treatment, the potted trees bearing the eggs were placed in a near-horizontal position. They were then sprayed from opposite directions to insure thorough coverage of both surfaces of the leaves. Insofar as was possible, the conditions of age of the eggs, distance from spray nozzle to tree, opening of the spray-gun—and hence character of the spray—and period of exposure to spray were standardized. All spraying was done by the same person. The trees were kept outdoors for a period of a week following spraying and were then transferred to a greenhouse to await the proper time for obtaining a detailed record on egg mortality.

The purpose of using a standard type orchard spraying machine for our tests rather than some laboratory device was the desire to study the oils under as nearly the same conditions as those existing when an orchardist would be using them. This is the normal condition. For the same reason we preferred to use eggs deposited on apple and quince foliage rather than on some artificial surface. Thus our findings can be utilized directly by those concerned with the practical use of oil sprays. But purely from an experimental viewpoint, when investigating such complex and dynamic systems as emulsions which are so much affected by the mechanics of their preparation and application, it appears sounder to us to study the problem first in its normal state before adaptations are attempted.

Table 2.—Analyses of oils tested with estimates of their insecticidal efficiency on apple foliage.

Oil Number	Saybolt Universal Viscosity Seconds at 100° F.	Unsulfonated Residue (A.O.A.C.) Per Cent	Gravity API° at 60° F.	Density $d_4^{20°}$	Aniline Point °C.	Refractive Index $n_D^{20°}$	Specific Refraction $r_D^{20°}$ (Lorentz-Lorenz)	Specific Dispersion at 20° C. (Gladstone Dale $\times 10^3$)	Approximate Minimum Effective Dosage Based on: Mg. oil per 100 sq. in. of leaf surface	Approximate Minimum Effective Dosage Based on: Per Cent oil in spray
41-D 20	56.6	64	24.3	.9044	59.0	1.4982	.3242	130	90	1.50
40-C 20	60.6	85	29.5	.8747	81.2	1.4770	.3230	107	75	1.25
41-D 21	61.1	94	29.3	.8761	85.9	1.4753	.3215	102	60	1.00
42-D 21	54.1	94	29.7	.8738	83.2	1.4740	.3216	101	65	1.00+
40-A 21	61.5	75	31.2	.8660	81.4	1.4821	.3293	128	25	0.50+
41-G 22	79.7	88	32.8	.8574	96.0	1.4711	.3261	105	12	0.375−
41-G 20	69.6	88	33.8	.8517	95.5	1.4689	.3269	105	15	0.375
41-H 20	59.6	71	34.2	.8502	88.5	1.4725	.3297	118	30	0.50+
41-G 21	60.0	89	35.3	.8443	95.0	1.4658	.3279	107	14	0.375+
41-G 23	69.7	93	36.0	.8410	102.3	1.4633	.3277	102	13	0.375
41-A 20	64.2	88	36.4	.8386	99.1	1.4639	.3289	104	12	0.375−
41-M 20	68.9	96	36.6	.8379	103.7	1.4620	.3281	101	8	0.25
42-M 20	69.3	94	36.5	.8383	103.8	1.4620	.3280	101	8	0.25+

Oil deposit determinations were made on each of the spray lots tested. In most of the earlier analyses essentially the same technique was followed as we used in determining deposits on bark (Pearce *et al.* 1941). With the leaves, however, the sample consisted of 50 to 100 leaf discs, usually a single disc being punched out of each leaf used. The oil present was extracted with petroleum ether in a Soxhlet extraction outfit. The quantity of oil recovered was then determined by weight; that is, by deducting the weight of the extract of unsprayed blanks from that found for the treated lot. Data obtained by this method is not wholly satisfactory, being rather undependable in measuring deposits laid down by low concentrations of oil. The possibility of measuring the oil in the extract by optical means was investigated in 1942 with encouraging results. The deposit values shown in table 5 and figure 2 were obtained through a combination of the weight and optical data. We plan to publish in a separate article a report on methods of determining oil deposits on the foliage of deciduous fruit trees.

OIL COMPOSITION.—As in the case of dormant oils (Pearce *et al.* 1942) we have employed a number of physical properties as a general index to the composition or constitution of the oils included in the present report. Unfortunately, the Waterman analysis, viscosity index, and some of the other indices of composition are not readily applicable to these lighter types of oils. However, the properties which are given in table 2 are sufficient to definitely classify the oils as to general constitution. In the reference cited are descriptions of the methods used to obtain these data and the significance of each of the properties.

Recent recommendations (Western Spray Conf. Rept. 1942) for areas where summer oils are extensively used are based principally on viscosity, distillation range, and unsulfonated residue. While data of this nature apparently show a correlation to the phytotoxic behavior of oils, no precise information seems to be available which clearly correlates these properties with insecticidal action.

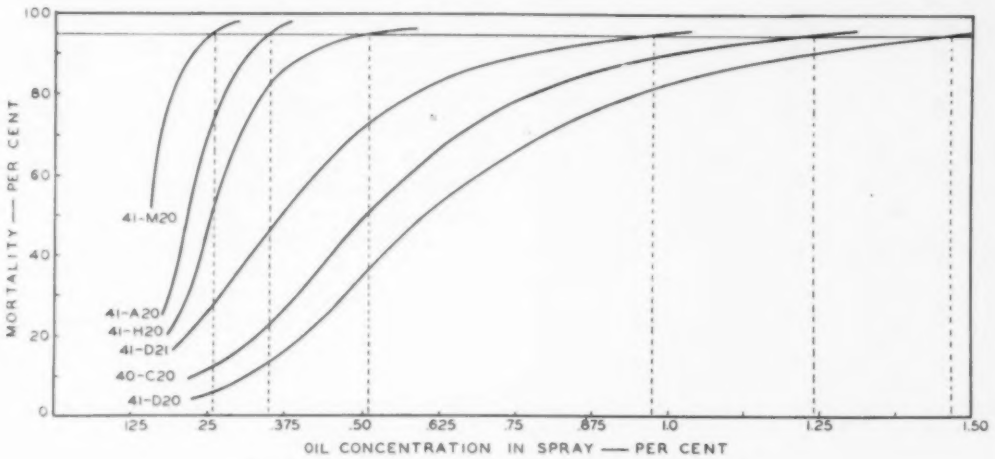

FIG. 1.—Graphic presentation of data given in table 3.

Spray oils have been selected mainly on the basis of viscosity at a single temperature, that is, 100° F. This is probably an outgrowth of the common use of viscosity in specifying oils for lubricating purposes. Strictly speaking, viscosity is simply a measure of a specific physical property and it is doubtful whether viscosity in itself is of importance in the killing action of oils. The real significance of viscosity to spray oils lies mainly in its relation to molecular size for which viscosity provides a rough measure. However, oils of the same viscosity may differ widely in their chemical composition. In any critical consideration of the insecticidal efficiency of oils, both the effect of variable molecular weight and fundamental chemical composition should be evaluated. The relation of chemical composition to efficiency of dormant oils has already been

established (Pearce *et al.* 1942) and the same relationship for summer oils is shown in the present paper. Preliminary work has been conducted on the influence of molecular size on insecticidal efficiency and

Table 3.—Results obtained with six oils using eggs of the oriental fruit moth and codling moth on apple foliage, 1941.

Oil Number	Per Cent Oil in Spray	Oriental Fruit Moth: Total number eggs	Oriental Fruit Moth: Per Cent mortality	Codling Moth: Total number eggs	Codling Moth: Per Cent mortality
41-D 20	0.125	504	3.2	97	3.1
41-D 20	0.250	1179	3.2	334	2.7
41-D 20	0.375	415	16.3	127	14.4
41-D 20	0.500	739	36.1	89	47.2
41-D 20	0.625	430	53.6	52	61.5
41-D 20	1.000	381	92.9	226	89.6
41-C 20	0.250	405	11.1	50	13.1
41-C 20	0.375	760	21.1	185	24.3
41-C 20	0.500	732	52.0	69	54.4
41-C 20	0.500	924	48.5	672	64.7
41-D 21	0.250	762	27.7	391	22.6
41-D 21	0.375	1174	52.0	87	50.9
41-D 21	0.500	753	72.2	95	59.4
41-H 20	0.125	498	7.4	57	12.1
41-H 20	0.250	504	53.2	263	50.9
41-H 20	0.375	918	89.4	172	85.4
41-H 20	0.750	521	97.7	395	97.5
41-H 20	1.000	221	98.6	360	99.1
41-A 20	0.125	940	22.9	131	19.5
41-A 20	0.1875	423	77.2	252	70.5
41-A 20	0.250	248	69.1	359	65.5
41-A 20	0.3125	382	80.4	41	79.5
41-A 20	0.375	524	97.5	178	93.8
41-A 20	0.375[1]	475	99.7	135	95.2
41-M 20	0.250	2008	97.4	—	—
41-M 20	0.375	961	98.6	395	97.8
41-M 20	0.500	1216	99.1	305	92.5
Controls (3)	—	1115	2.1	184	3.8

[1] On quince foliage.

within limits the indication is that it is much less important than chemical composition. We hope to report later on the full significance of molecular weight in the performance of spray oils.

That volatility or rate of evaporation of petroleum fractions may be of importance with spray oils seems apparent. It is related both to chemical composition and molecular weight. Various tests are used as an indication of volatility such as "distillation range" and the evaporation test (Marshall 1931). Vapor pressure measurements can also be made. However, the relation of the results of these tests to the insecticidal efficiency of oils is not clear. Vapor pressure data have been obtained on some of the oils studied but will not be presented in this introductory report.

Discussion of Results.—Data of the type obtained may be presented in several ways when computing the efficiency of treatment. The principal variables to be adjusted are the differences in kill of eggs on the two leaf surfaces (Table 5 and Fig. 2) and the unequal distribution of eggs between the two surfaces (Tables 1 and 5). A distinction also must be made whether efficiency is to be based on the concentration of oil in the spray-tank or the amount deposited on the leaves. In the former instance one may restrict the value shown to the kill on a single surface—probably in the present case to the upper surface—or strike an average for the two surfaces. Such an average of course should be weighted. And so that comparisons can properly be made between treatments, one should apply some factor to the data based on the distribution ratio of eggs on the two surfaces. The data given in table 1 should provide suitable ratios for each series of tests.

In the present paper we elected to express the efficiency data as averages of the percentage kill found on each surface. They are not weighted. This is done to place the efficiency values on the same basis as those for the oil deposit. For, the quantity of oil removed in the analysis of a leaf sample represents the recovery from equal areas of upper and lower surface. It is assumed more oil is deposited on the hairy lower surface because of the more rapid achievement of control on this surface as oil concentration is increased. (See Table 5 and Fig. 2).

Table 4.—Comparative susceptibility of bud moth and oriental fruit moth eggs to oil sprays, 1942.

Oil Number	Oil Deposit in mg. per 100	Per Cent Oil in Spray	Bud moth: Total number eggs	Bud moth: Per Cent mortality	Oriental Fruit Moth: Total number eggs	Oriental Fruit Moth: Per Cent mortality
41-M 20	3.3	0.0625	236	15.2	315	13.4
41-M 20	10.8	0.1875	261	75.6	1054	69.2
41-M 20	25.0	0.250	167	100.0	356	98.9
41-D 21	15.0	0.250	326	20.5	281	25.7
41-D 21	29.2	0.500	207	48.1	466	48.4
41-D 21	82.5	0.875	415	76.7	809	76.8
Controls	—	—	714	4.9	396	2.6

In tables 3 and 4 we give some evidence on the comparative efficiency of the oils to eggs of oriental fruit moth, codling moth, and bud moth. No consistent differences in susceptibility of the eggs of the three species to the treatments were detected. Where considerable discrepancies in kill were found in some lots, it was in instances where a species was represented by a

rather small number of eggs. Schoene & Jefferson (1935) have previously called attention to the similarity in response of codling moth and oriental fruit moth eggs to summer oil sprays.

Perhaps the most significant point revealed in the present report is that oils heretofore used more or less interchangeably as summer oil spray stocks may differ widely in their efficiency. As an extreme example, approximately ten times as much 42-D 21 oil was required to effect control as with 42-M 20, as shown by the data given in table 5. ("Control" may be assumed achieved when the mortality curve reaches 95 per cent.) We give in columns 10 and 11 of table 2 the estimated minimum effective dosage (M.E.D.) or deposit for each of the oils used. Attention is called to the fact that we have based the M.E.D. values in table 2 on data obtained on apple foliage. A pronounced difference in slope of the upper portion of the mortality curve was observed between quince and apple foliage in the case of naphthenic oils, particularly oil D 21 (Figs. 1 and 2). This difference is apparently confined to the data obtained on the upper surfaces since the kill on the lower surface in each case was essentially the same. We believe further studies will show this to be due to the effect of surface character on oil deposition. With the more efficient oils (paraffinic) this effect is not detected because of the steepness of the mortality curves.

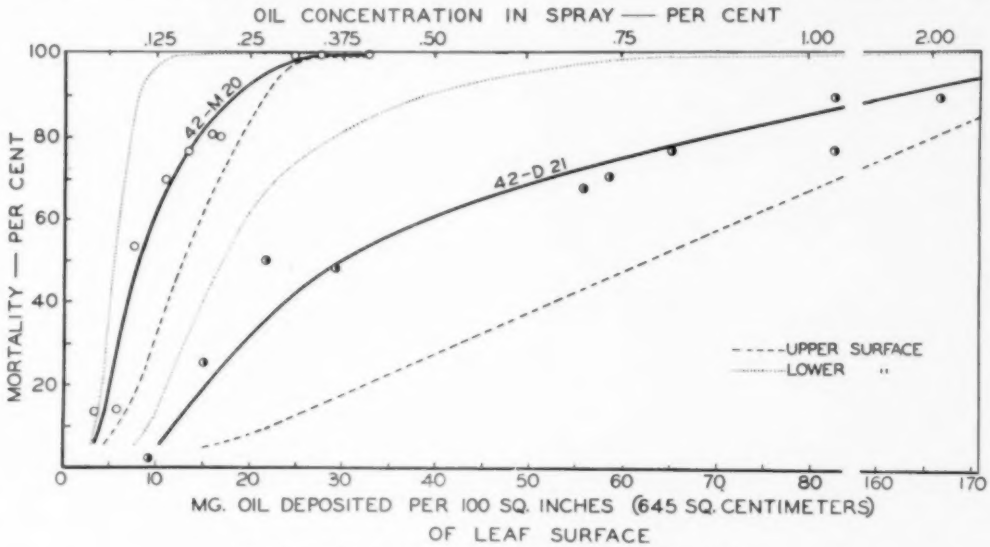

FIG. 2.—Graphic presentation of data given in table 5.

The M.E.D. values given in table 2 are related to such properties of the oils as gravity or density, aniline point, refractive index, and specific dispersion. These properties are indicative of the general structural constitution of the oil or the proportions of major hydrocarbon groups present. A high correlation is exhibited between efficiency and what may be termed the "paraffinicity" of the oils tested. This is especially evident if one applies such indicators of paraffinic character as gravity and the aniline point values. Within a given viscosity range, the paraffinic structures in oils are known to increase as gravity and aniline point increase. The evidence seems clear, therefore, that within limits the greater the paraffinic chracter of an oil the more efficient it is against eggs of the three insects under discussion. This same relationship has already been shown to apply to the fruit tree leafroller using dormant type spray oils (Pearce *et al.* 1942).

The idea appears to be commonly held that the aromatic and other unsaturated structures in an oil—roughly, the part which reacts with sulfuric acid to form a *sulfonated residue*—are insecticidally quite potent. Thus, by implication, they are thought to contribute more to control than the saturated structures present. This generalization is stated, in effect, as recently as 1941 by Ebeling (1941). While oils containing approximately 30 per cent

aromatics and other unsaturates may be more effective against certain pests than more highly refined products having say 5 per cent of these constituents, this relationship has not been evident either in the present series of tests or in our work on fruit tree leafroller and red bug using dormant oils (Chapman *et al.* 1941; Pearce *et al.* 1942). On the contrary, our evidence oils to plants in foliage. Thus, the constituents which are caustic or harmful to a plant must likewise be the most active or efficient where insectidal action is involved. While our evidence would seem to refute this analogous type of reasoning, we do not wish to be understood as believing all insects and mites will respond in the same manner. Aphid eggs, for example,

Table 5.—Results obtained in tests of a paraffinic oil (42-M 20) and a naphthenic oil (42-D 21)—using oriental fruit moth eggs on quince foliage, 1942.

Oil Number	Oil Deposit in Mg. per 100 Sq. In.	Per Cent Oil in Spray	Upper Surface		Lower Surface		Average Mortality Both Surfaces
			Number eggs	Per Cent mortality	Number eggs	Per Cent mortality	
42-M 20	3.3	0.0625	202	9.9	53	16.9	13.4
42-M 20	5.8	0.0625	1011	8.5	106	18.8	13.6
42-M 20	7.5	0.125	579	17.4	159	89.9	53.6
42-M 20	10.8	0.1875	834	39.8	220	98.6	69.2
42-M 20	13.3	0.125	460	55.0	99	98.9	76.9
42-M 20	15.8	0.250	261	63.9	74	97.3	80.6
42-M 20	16.7	0.1875	584	59.4	159	100.0	79.7
42-M 20	—	0.250	645	86.5	176	100.0	93.2
42-M 20	25.0	0.250	234	99.6	122	98.3	98.9
42-M 20	27.5	0.3125	293	98.9	422	100.0	99.4
42-M 20	—	0.375	269	96.3	129	100.0	98.1
42-M 20	32.5	0.375	373	99.2	150	100.0	99.6
42-M 20	—	0.500	90	100.0	35	100.0	100.0
42-D 21	9.2	0.125	261	3.4	183	1.1	2.2
42-D 21	15.0	0.250	215	4.6	66	46.9	25.7
42-D 21	21.7	0.375	239	25.9	84	73.8	49.8
42-D 21	29.2	0.500	342	17.8	124	79.0	48.4
42-D 21	55.8	0.625	437	40.9	88	94.3	67.6
42-D 21	59.1	0.750	208	43.7	47	97.9	70.8
42-D 21	65.0	1.000	943	54.1	211	100.0	77.0
42-D 21	82.5	0.875	731	53.7	78	100.0	76.8
42-D 21	82.5	1.500	1477	80.9	640	97.3	89.1
42-D 21	166.0	2.000	279	84.2	169	95.9	90.1
Controls (2)	—	—	396	3.5	54	1.8	2.6

is that efficiency is increased as the aromatic content of an oil is decreased. This point is illustrated for both naphthenic and paraffinic type oils in figure 1 and table 2. The naphthenic series includes 41-D 20, 40-C 20, and 41-D 21, and they are listed in order to decreasing aromatic content as indicated by the values for specific dispersion and unsulfonated residue. The same relation is shown for the paraffinic series 41-H 20, 41-A 20, and 41-M 20. Thus the data indicate that for the species studied the aromatic constituents are virtually negative in their insecticidal action, serving principally as diluents.

Probably the belief that the lowering of the aromatic content of an oil results in a lessening of insecticidal efficiency stems from the relationship known to exist between these structures and the safeness of are quite resistant to dormant-type petroleum oils (Chapman *et al.* 1941). However, they are very susceptible to low concentrations of tar oils which are predominantly aromatic in nature. Conversely, the tar oils show little evidence of toxicity at usual spray concentrations to eggs of the fruit tree leafroller.

Martin (1936) has discussed the foregoing subject and concludes insect eggs may fall into two general groups in their reaction to hydrocarbon oil sprays. Products composed largely of aromatic structures are effective against eggs of psyllids and aphids. The action in this case is "chemical" or "toxic." With the other class of eggs the oil destroys by physical action; that is, kill is dependent on envelopment and "stifling" of the eggs. For the latter group, he reasons, there would be an ad-

vantage in having stability and persistence, both of which characterize the saturated structures in petroleum oils. While our studies lend support to Martin's hypothesis, extensive investigations of a wide variety of insect species is required before the validity of this concept can be accepted.

Some indication of the role of viscosity, or more properly, molecular weight, is provided by the data given in table 2. In particular one should compare oils 41-G 21, 41-A, 20, 41-G 20, and 41-G 22.

Attention is called to this group because the viscosity range is appreciable and also for the reason that chemical composition, as indicated by their physical constants, is apparently similar. While the variations in viscosity may be due in part to differences in molecular structure, it is more probable that they are primarily related to differences in molecular weight. The insecticidal data suggest that efficiency has not been affected appreciably by the variations in viscosity shown by these four oils.

SUMMARY.—A number of petroleum fractions of the so-called summer-type spray oils were tested to determine their efficiency in killing eggs of the oriental fruit moth, the codling moth, and the eye-spotted bud moth. Efficiency was found related to the chemical composition of the oils. Thus, the oil most predominantly paraffinic in character was found ten times more efficient than some of the so-called naphthenic type. Contrary to common belief, highly refined or white oils were more efficient than the corresponding less refined products. In other words, efficiency was increased with the removal of the aromatic constituents. The three species of insects studied showed no significant difference in their response to the oils tested.[1]

[1] The writers desire to acknowledge the kindness of Professor M. R. Fenske of the Petroleum Refining Laboratory of the Pennsylvania State College in reviewing the manuscript.

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DR. CARLOS PORTER AND DR. FRANCISCO CAMPOS

Through a correspondent of Dr. Carl J. Drake comes the news of the death of Dr. Carlos Porter, Casilla 2974, Santiago, Chile. The death followed an operation.

Dr. Porter was the editor of *Revista Chilena de Historia Natural*. His primary interest was entomology and he was Professor of Entomology at the University of Santiago.

From the same source comes news of the death of Dr. Francisco Campos. Apartado No. 484, Guayaquil, Ecuador. Dr. Campos was professor of Zoology and Entomology at the University of Guayaquil.

Attractiveness of Certain Plant Constituents to the Japanese Beetle[1]

GEORGE S. LANGFORD, MARTIN H. MUMA, and ERNEST N. CORY, *University of Maryland, College Park*

In the operation of Japanese beetle traps a mixture of the chemicals geraniol and eugenol has been used as a successful attractant. The War has so threatened normal supplies of these materials that it seemed expedient to find practical substitutes should these materials become wholly unavailable. With this in mind studies on attractants have been intensified. The results obtained to date have not solved the major objective, but they have been revealing and it is believed they will aid in future studies on attractants.

The data collected gave evidence which appears fundamental for studies on Japanese beetle bait formulas. The data indicate:

1. There are probably many chemicals, particularly of plant origin, attractive to the Japanese beetle.

2. These attractants may be found among the alcohols, acids, oils, esters, and aldehydes as well as other chemicals.

3. Mixtures of these attractants were, on a whole, more attractive than any component.

4. Some attractants are more effective with a non-attractive diluent than in concentrated form.

METHODS.—As a background for these studies an attempt was made to study the attractive value of some of the chemicals known to exist in preferred hosts. Materials produced in the Americas were given special attention. The chemical literature was searched for data on the analyses of plants and fruits most susceptible to beetle damage. Chemicals found to be common in these plants, as well as other possible attractants, were tested in standard Japanese beetle traps equipped with standard quarter- and half-inch cotton wicks. All equipment was standardized and was the same for each test. The traps were set in batteries at 10-foot intervals and each bait was replicated at least once in each battery. Traps were emptied and beetles counted at 24-hour intervals.

When mixtures of materials were employed the proportion of one material to another was made on an arbitrary basis. Therefore, in some cases the most effective proportions or combinations may have been used; in other cases it is probable that different proportions or combinations would have been more effective. For the purpose of computing values a combination of 90 parts of geraniol and 10 parts of eugenol has been disignated as the standard, and was given the value of 100.

The chemicals, compounds or other materials used varied in grade from pure, to technical and commercial grades. Data on the grades of the products used are tabulated in the listings. In cases where chemicals or compounds of commercial or technical grades were used the ratings obtained probably deviated slightly from those that would have been obtained with the pure product. All data presented are based on averages which on a whole are believed to represent comparative relationships. It should be pointed out that in future tests these relationships may vary slightly, depending on the number of traps used, the grade and the relative attractiveness of the material used. An analysis of the data showed that in the case of the standard bait in which a total of 123 traps were used, individual traps varied in catch as much as 20 per cent both above and below the average. In the case of empty traps of which 33 were used, the variation was as much as 2 per cent above or below the average. The total number of traps used in testing each attractant is given in the tables of the results.

ATTRACTIVE MATERIALS.—Richmond (1927) pointed out that the oils of sassafras, hemlock, mustard, lemon and isoamyl valerate were somewhat attractive to the beetle. He stated that geraniol is clearly the primary attractant of the Japanese beetle, but its combination with eugenol increases its effectiveness. He showed that citronellal, citral, citronellol and diphenyl ether were all attractive, but due to the fact that the concentrations that he used were not standardized, the comparative values he showed for them as they relate to geraniol are probably misleading.

A positive analysis of data published by

[1] Eastern Branch Program, New York, November 1942.

Metzger & Maines (1935) reveals that certain materials common as impurities in commercial geraniol are highly attractive when compared with his standard or check, which consisted of a mixture of 10 parts of geraniol and 1 part of eugenol. An analysis of the data indicates that citronellol caught approximately 54 per cent, citronellal 31 per cent, geranyl acetate 43 per cent, and geraniol sesquiterpenes 61 per cent, as many beetles as the standard check.

Tests at the University of Maryland using a total of 52 materials, most of them of plant origin, indicated that at least 30 had attractive qualities.

Of the essentially pure chemicals the best attractants were found among the alcohols. Geraniol and eugenol[1] were best with values of 68.3 and 62.6 respectively. Other alcohols with definite attractive values include citronellol, phenyl ethyl alcohol and linalool.

Several of the higher fatty acids were found to be decidedly attractive. Caproic, propionic and valeric with values of 28.6, 33.1 and 38.1 appeared to be the most attractive tested. Concentrated acetic acid did not seem to be attractive, but when diluted and added to certain other materials it seemed to enhance the attractiveness of the material to which it was added. Butyric acid was slightly attractive and had a value of 22.04.

Quite a number of essential oils were found to have value for attracting beetles. Undoubtedly the attractive value of any essential oil will depend on its source, the amount and concentration of the attractive constituents it contains, as well as the amounts of other materials which might tend to repel or mask the odor of the attracting materials. Pimento oil with a value of 54 was the most efficient of the oils tested. Other oils having attractive value included citronella 26.3, bay oil 18.6, coriander 24.3, cloves 20.7, sassafras 20.0, rose geranium 15.9, lemon grass 13.3 and linaloe 9.2.

Among the esters and aldehydes, methyl salicylate and benzaldehyde were found to be slightly attractive with values of 7.8 and 5.9 respectively. Other materials tested and their attractive values are given in Table 1.

MIXED MATERIALS AS ATTRACTANTS.—It is well established that when geraniol and eugenol are mixed the combination is more effective for attracting beetles than either material is when used alone. An attempt was made to determine attractive values of some of the other known attractants when mixed one with the other. It was soon quite obvious that in some instances the combinations were much more attractive than the unmixed constituents. While no new combinations were observed with sufficient merit to warrant a change from a geraniol-eugenol combination, data were obtained with

[1] Often referred to as an alcohol in the literature, but a weak phenolic acid.

Table 1.—Materials derived from plants as attractants for the Japanese Beetle.

MATERIAL	GRADE	CHEMICAL NATURE	VALUE AS AN ATTRACTANT BASED ON STANDARD AT 100	NO. TRAPS USED
Bay	Technical	Oil	18.68	8
Calamus	Technical	Oil	5.72	5
Camphor	Water white	Oil	3.22	5
Caraway	Technical	Oil	4.18	5
Cedarwood	Technical	Oil	2.68	5
Citronella	Technical	Oil	26.35	5
Cloves	U. S. P.	Oil	20.75	5
Copaiba	U. S. P.	Oil	1.82	5
Coriander	Technical	Oil	24.32	5
Corn	Refined	Oil	4.81	5
Eucalyptus	U. S. P.	Oil	2.21	5
Ginger	Technical	Oil	7.05	5
Lavender flowers	Technical	Oil	2.65	5
Lemon	Technical	Oil	7.14	5
Lemon grass	Technical	Oil	13.30	5
Linaloe	Technical	Oil	9.23	5
Neroli	Technical	Oil	4.21	5
Peppermint	Technical	Oil	2.90	5
Pimento	Technical	Oil	54.04	8
Pinene	Pure	Oil	3.61	5
Pine needles	M. M. & R.[1]	Oil	2.25	5
Rose geranium	Technical	Oil	15.97	5
Safrole	Technical	Oil	5.54	5
Sandalwood	Technical	Oil	3.51	5
Sassafras	Natural U. S. P.	Oil	20.09	8
Star Anise	Technical	Oil	47.93	7
Winter green	Technical	Oil	4.49	5
Ylang Ylang	Technical	Oil	5.98	5
Acetic (Glacial)	U. S. P.	Acid	2.50	5
Butyric	Technical	Acid	22.07	4
Propionic	Technical	Acid	33.12	4
Caproic	Technical	Acid	28.66	11
Formic	Technical	Acid	2.76	5
Palmitic	Technical	Acid	15.17	2
Stearic	U. S. P.	Acid	4.22	2
Valeric	Pure	Acid	38.76	11
Vinegar (5% acetic)	Commercial	Acid	15.17	2
Citronellol	Technical	Alcohol	15.94	5
Eugenol	U. S. P.	Pehnol	62.61	15
Geraniol	Technical	Alcohol	68.35	15
Linalool	Technical	Alcohol	9.15	5
Methyl alcohol	Absolute	Alcohol	2.34	5
Phenyl Ethyl	C. P.	Alcohol	8.20	5
Benzaldehyde	Technical	Aldehyde	5.94	5
Citral	Technical	Aldehyde	5.12	5
Citronellal	Pure	Aldehyde	3.96	5
Furfural	Technical	Aldehyde	3.08	5
Amyl cetate	Pure	Ester	7.51	3
Methyl Salicylate	Technical	Ester	7.80	5
Artificial apple flavors	Pure	Esters	12.43	2
Apple juice	Commercial	Esters	31.09	2
Buckwheat honey	Commercial	Sugars	6.00	1
Empty traps	—	—	3.08	33

[1] Magnus-Mabee & Reynard.

Table 2.—Known attractants derived from four favored foods.

Constituents[1]	Sassafras *Sassafras variifolium* Leaves	Peach *Prunus persicae* Ripe Fruit	Rose *Rosa spp.* Flower	Apple *Pyrus malus* Ripe Fruit	No. Plants with Constituent
Acetic acid	X	X	X	X	4
Benzaldehyde		X		X	2
Caproic acid				X	1
Citral			X	X	2
Citronellol			X		1
Eugenol	X		X		2
Geraniol	X		X	X	3
Linalool	X	X	X		3
Phenyl ethyl alcohol			X		1
Valeric acid	X	X		X	3
Total Constituents	5	4	7	6	

[1] It should be noted that although these materials are listed as being pure, they occur most often in combination with each other and with other constituents of plants.

apparent fundamental aspects which if explored may lead, through combination, to greatly improved attractants. These aspects were observed too late in the season to test them fully, but an analysis of published data as well as an analysis of the relation of host preference to plant constituents tends to support the findings.

Richmond (1927), Van Leeuwen & Metzger (1930), and Fleming, *et al.* (1940) are among those who have pointed out that a mixture of geraniol and eugenol is a more effective attractant than either material when used alone. But according to the data in table 3, the most effective combination of these two chemicals probably has not yet been revealed. The data indicate that if the eugenol content is increased to the ratio of 75 parts of geraniol to 25 of eugenol, the bait is more efficient than the standard formula. A formula consisting of 50 parts of geraniol and 50 parts of eugenol was slightly less efficient than the standard.

Passing from the geraniol and eugenol combination, an analysis of Richmond's early work (1927) indicates that substances other than geraniol and eugenol must have been exerting an attractive influence. He reported that geraniol used for soaps was definitely better than pure geraniol (83 per cent). The work of Metzger & Maines (1935) which resulted in lowering recommended specifications for geraniol, shows that chemicals once thought of as undesirable were really an asset. In other words many technical grades of geraniol were more attractive than the purer grades. In 1933 Metzger found by adding phenyl ethyl alcohol, a comparatively weak attractant, the attractive value of the geraniol and eugenol combination was increased.

Favored food plants exceed present standard baits in attractiveness. Chemical data on the chemical constituents of the many hosts of the beetle are not available, therefore, it is not possible to correlate chemical constituents and host preference. There is considerable data on the analyses of sassafras leaves, ripe apple fruit, ripe peach fruit and the flowers of rose. The chemical data consulted show that a total

Table 3.—The value of mixed attractants as compared with unmixed constituents.

Materials	No. Parts	No. Traps	Test Value: Material	Test Value: Mixture	Nature of Chemical
Mixture only slightly more attractive than best constituent					
Pimento	50		54.04		Oil
Ethyl alcohol	50	8	no test	64.33	Alcohol
Valeric acid	90		38.76		Acid
Pimento	10	4	54.04	68.43	Oil
Sassafras	50		20.09		Oil
Pimento	50	10	54.04	57.34	Oil
Bay	50		18.68		Oil
Sassafras	50	6	20.09	31.22	Oil
Mixture approaches sum of the values of the constituents					
Geraniol	90		68.35		Alcohol
Eugenol	10	123	62.61	100.00	Phenol
Geraniol	75		68.35		Alcohol
Eugenol	25	15	62.61	108.48	Phenol
Geraniol	50		68.35		Alcohol
Eugenol	50	15	62.61	99.38	Phenol
Pimento	90		54.04		Oil
Eugenol	10	11	62.61	95.02	Phenol
Caproic acid	50		28.66		Acid
Pimento	50	4	54.04	72.23	Oil
Sassafras	90		20.09		Oil
Bay	5		18.68		Oil
Caproic acid	5	5	28.66	50.73	Acid
Mixture exceeded sum of the values of the constituents					
Valeric acid	50		38.78		Acid
Linaloe	50	4	9.23	54.81	Oil
Caproic acid	50		28.66		Acid
Sassafras	50	4	20.09	49.16	Oil
Citronella	90		26.35		Oil
Cloves	5		20.75		Oil
P. E. A.*	5	10	8.20	68.82	Alcohol
Valeric acid	90		38.76		Acid
Bay	10	4	18.68	75.34	Oil
Valeric acid	90		38.76		Acid
Sassafras	10	4	20.09	69.40	Oil
Mixtures less attractive than best constituent					
Cloves	90		20.75		Oil
Pimento	5		54.04		Oil
P. E. A.	5	4	8.20	34.17	Alcohol
Sassafras	90		20.09		Oil
Eugenol	10	7	62.61	43.83	Phenol
Propionic acid	80		33.12		Acid
Pimento	20	4	54.04	43.29	Oil
Bay	50		18.68		Oil
Pimento	50	6	54.04	44.19	Oil

* Phenyl ethyl alcohol.

of 10 known attractants have been isolated from these four preferred hosts. It is interesting to note, in table 2, that flowers of rose contained 7 attractants, ripe apple fruit 6, sassafras 5, and ripe peach fruit 4. Geraniol was reported from 3 and eugenol from only 2. Other attractants reported from one or more of these hosts include acetic acid, valeric acid, caproic acid, citral, linalool, benzaldehyde, citronellol and phenyl ethyl alcohol.

It should be stated that the attractants reported in the above preferred foods were assembled from results of several different analyses. All attractants shown in Table 2 were not from any one analysis. In instances, particularly in the cases of ripe apple fruit and ripe peach fruit, the chemists did not give complete analyses and did not work with the same varieties of fruits. The variety question presents another rather interesting problem. In the case of foliage, the extent of damage depends upon the variety. This is evidenced in both apple and grape, as well as in a number of other plants. In a study of the resistance of the foliage of apple varieties to Japanese beetle injury, it was found that the range of susceptibility to feeding was wide. Varieties like Transparent and Williams may have from 90 to 100 per cent of the foliage completely destroyed, whereas a variety like Courtland even though growing adjacent will have less than 10 per cent of the foliage showing damage. The same conditions exist for grape. The variety Delaware may be completely defoliated while the variety Champarrel, growing in the same vineyard, will not be injured. It is not known whether these differences are due to chemical or to physical factors, but both probably play a part

It was found on the basis of seasonal averages that combinations were on a whole more attractive than the constituents when used separately. This was found to be true for mixtures consisting of alcohols and phenols, oils and alcohols, oils and acids, and oils and oils. Table 3 show that in 19 different combinations 15 exceeded the value of any one constituent when used alone. In four instances the attractive values were less than that for a single constituent. In 5 cases the combinations were more attractive than the combined values of all the attractants in the mixture.

Without absolutely pure chemicals and without consideration of both the physical and chemical properties of each and their relationship one with the other, which is beyond the scope of this paper, it is impossible to evaluate combinations. Undoubtedly the ratio of the materials one to the other has an influence, as has been shown for geraniol and eugenol, but it is noteworthy to observe that where comparatively pure chemicals such as eugenol, caproic acid and valeric acid were combined in equal volume with another substance, the value of the mixture, approached or slightly exceeded the sum of the values of the two substances. In some instances where unequal volumes were used the resulting attractive value not only equaled but surpassed the sum of the values of the substances. Wide variation occurred when some of the essential oils were mixed. This could be expected as they are of a complex chemical nature and may contain repelling or masking as well as attractive ingredients. Clove oil might well serve as an illustration. It has a comparatively low attractive value, yet its main constituent is eugenol 75 to 98 per cent.

The factor of concentration which in turn may be tied up with evaporation appears important. Results have been obtained which indicate some attractants may be equally, or more, effective with a diluent than in the concentrated form. A review of unpublished bait test work done at the University of Maryland several years ago in which the principal attractants were mixed with a neutral or non-attractive material such as glycerine showed that the addition of glycerine did not reduce the attractive value of the bait in proportion to the amount of glycerine added. A mixture containing 8 parts of a combination of glycerine and ethyl alcohol and 2 parts of attractant caught only 10 per cent fewer beetles than did the concentrated attractant undiluted by glycerine. Results obtained in these experiments indicate that certain attractants may be diluted by certain apparently non-attractive materials without materially injuring their attractive qualities. Table 3 shows that a mixture consisting of 1 part of pimento oil and 1 part of ethyl alcohol had an attractive value approximately 10 per cent greater than pimento oil. Likewise, a 1 to 1 mixture of caproic acid and ethyl

alcohol had an attractive value of 54 whereas caproic acid alone had a value of only 28.

SUMMARY.—Tests with 52 chemicals principally of plant origin or derivation showed that at least 30 were to some degree attractive to the Japanese beetle. Attractants were found among the essential oils, alcohols, acids, aldehydes and esters. It was found that combinations of these attractants were, on a whole, more attractive than the constituents when used separately. In 19 different combinations, 15 exceeded the value of any one constituent when used alone. In 4 instances the attractive values were less than that for a single constituent. In 5 cases the combinations were more attractive than the combined value of all the attractants in the mixture. It was observed that where comparatively pure chemicals such as eugenol, caproic acid and valeric acid were combined in equal volume with another substance the value of the mixture approached or slightly exceeded the sum of the value of the two substances. In some instances mixtures of unequal volume exceeded in value the sum of the values of the constituents. Wide variations occurred when some of the essential oils were mixed. It was pointed out that this could be expected due to their complex chemical nature and the possibility of ingredients that might repel beetles or mask attractive ingredients. Observations indicated that certain attractants could be diluted with apparently non-attractive substances without materially injuring attractive values.

The results obtained in these studies indicate possibilities for improved baits as well as substitute attractants for the present standard bait.—1-11-43.

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WASHINGTON STATE QUARANTINES

Washington State quarantine orders were revised March 30, 1943, to lift the restrictions pertaining to peach yellows, peach rosette, and little peach, as they relate to the States of Kansas, Louisiana, Missouri, New Hampshire, and Texas; to include Ventura County, Calif., with other areas in California recently placed under regulation for the Oriental fruit moth; to add infested counties in Iowa and Missouri to the area regulated under the European corn borer quarantine, and to lift the restrictions of this quarantine as to celery, oat and rye straw, cosmos, zinnia and hollyhock; and to provide for methyl bromide fumigation for grape phylloxera.

Influence of Carbon Tetrachloride on the Toxic Efficiency of Certain Volatile Organic Compounds[1]

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The use of mixed gases for the fumigation of insects holds two possibilities: first, a reduction of the fire hazard of inflammable but otherwise satisfactory fumigants; and, second, an increase in toxicity or synergism. Synergism and antagonism in drugs have long been recognized and Bancroft & Richter (1931) explain both as a result of the displacement of one drug by another from a given substrate. Toxicologically, synergism is a toxicity greater than the additive effect of the components, and antagonism is a less than additive effect. The study of synergism is a promising field of investigation and criteria should be established for separating it from other types of joint action. The object of this investigation was to determine the effect of carbon tetrachloride on the toxicities of methyl bromide, methyl formate and ethylene dichloride to the red flour beetle, *Tribolium castaneum* (Herbst).

The toxicity of carbon tetrachloride to insects has been investigated by numerous workers. One of the earliest was Britton (1908a, 1908b) who tested it against the San Jose scale on nursery stock. Tattersfield & Roberts (1920), Neifert *et al.* (1925), Strand (1927), Roark & Cotton (1928), Shepard *et al.* (1937), Gunderson (1940) and others have demonstrated the low toxicity of carbon tetrachloride to insects.

Neifert *et al.* (1925) investigated the toxicity of ethylene dichloride to grain insects. Further tests were conducted by Roark & Cotton (1928, 1929). Shepard *et al.* (1937) found it much more toxic than carbon tetrachloride and less toxic than methyl formate to *Tribolium confusum*, *Sitophylus granarius* and *S. oryza*.

The relatively high toxicity of methyl formate to grain insects was demonstrated by Neifert *et al.* (1925) and further investigated by Cotton & Roark (1928) and Roark & Cotton (1929). Lehman (1933) found methyl formate to be twice as toxic to the wireworm, *Limonius californicus*, as ethylene dichloride. Jones (1938) found it to be less toxic than ethylene oxide and methyl bromide to *Tribolium castaneum*.

The first investigator to report the insecticidal value of methyl bromide was Le Goupil (1932). A detailed account of its properties, history and uses is given by Mackie (1938). Laboratory tests against a number of insect species have shown methyl bromide to be a fumigant of high toxicity. Fisk Shepard (1938) found that its toxicity compared favorably with that of hydrogen cyanide, chloropicrin and ethylene oxide. Shepard & Buzicky (1939) determined its toxicity to a number of stored-product pests. *Attagenus piceus* was the most resistant species tested. Grayson & Swank (1941) found the firebrat, *Thermobia domestica*, to be less resistant than any of the insect species so far investigated. Hamilton (1941) in tests with methyl bromide against the common red spider on greenhouse roses found that the kill at any temperature was essentially a product of the length of exposure and the concentration of methyl bromide.

Neifert *et al.* (1925) tested a number of mixtures against grain insects and found that, other than carbon disulfide, a mixture of ethyl acetate and carbon tetrachloride was the most promising fumigant for weevils in grain cars. Back & Cotton (1925) recommended a mixture of ethyl acetate and carbon tetrachloride for the fumigation of grain cars. This mixture was not inflammable but was later found to leave an objectionable odor in the grain.

Hazelhoff (1928) noted that carbon dioxide has a marked effect on the respiratory movements of several insect species and suggested that it might be used to increase the insecticidal action of gases.

Brinley & Baker (1927) reported that a small amount of methyl acetate seemed to increase the toxicity of liquid hydrogen cyanide. Pratt *et al.* (1933) reported that carbon dioxide reduced the toxicity of hydrogen cyanide to ladybird beetles, but Cupples *et al.* (1936) found that it increased the toxicity of hydrogen cyanide to the red scale.

Cotton & Young (1929), Cotton (1930) and Back *et al.* (1930) found that the addition of carbon dioxide increased the effec-

[1] Eastern Branch Program, New York, November 1942.

[2] The investigation was conducted at the Iowa State College under the guidance of Dr. C. H. Richardson while the author was on leave of absence from the Virginia Agricultural Experiment Station. Acknowledgment is made to Dr. I. B. Johns for suggestions regar ling the apparatus.

tiveness of ethylene dichloride, methyl chloroacetate, carbon disulfide, chloropicrin and ethylene oxide. Cotton (1932) found that the amount of carbon dioxide to give the maximum increase in toxicity varied with different gases. Jones (1938) showed that carbon dioxide markedly increased the toxicity of methyl bromide,

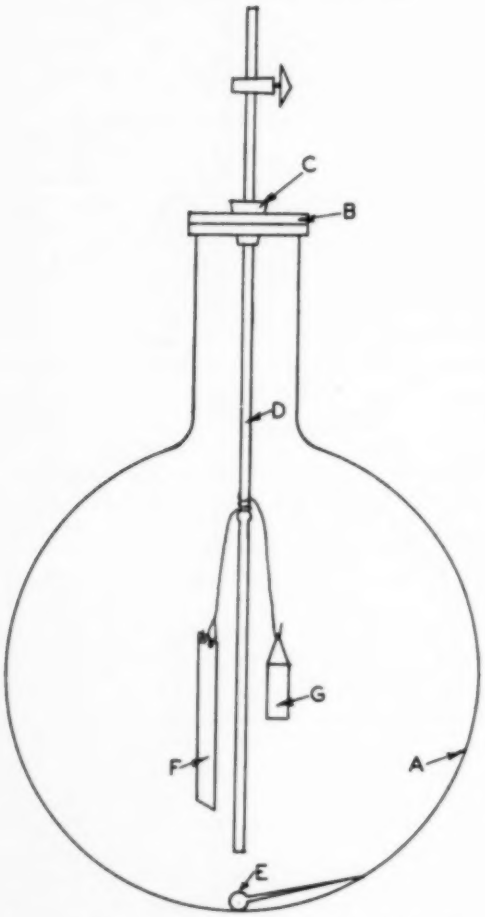

FIG. 1.—Diagram of apparatus used in fumigation experiments.

methyl formate and ethylene oxide to *Tribolium castaneum* but that it might lower the toxicity of the mixture when used in excess of the amounts necessary to produce the maximum increase in effectiveness.

Shepard & Lindgren (1934) obtained antagonism when ethylene dichloride or propylene dichloride was mixed with carbon tetrachloride. The mixtures contained 25 per cent carbon tetrachloride. *Tribolium confusum* and *Sitophilus oryza* were the insects used.

Gunderson (1940) used sublethal concentrations of ether and showed that the toxicity of carbon disulfide and carbon tetrachloride to *Tribolium confusum* increased as the concentration of ether increased but that the toxicity of ethyl acetate decreased.

EXPERIMENTAL METHOD.—The specifications of the fumigants used in the investigation are given in table 1. With the exception of methyl bromide they were purified by distillation and their purities tested by determining their refractive indices.

Table 1.—Specifications of materials.

MATERIAL	BOILING POINT	REFRACTIVE INDEX
Methyl formate ($HCOOCH_3$)	31.0°C. at 728.9 mm and 26.0° C.	1.3449 (15° C.)
Methyl bromide[1] (CH_3Br)	4.6° C.	
Ethylene dichloride (CH_2ClCH_2Cl)	82.0° C. at 741.7 mm and 25.5° C.	1.4441 (20° C.)
Carbon tetrachloride (CCl_4)	75.1° C. at 739.5 mm and 26.0° C.	1.4594 (20° C.) 1.4597 (20° C.) [2]1.4593 (20° C.)

[1] Obtained from Dow Chemical Co.; not less than 99.4 per cent CH_3Br; inert ingredients, not more than 0.6 per cent.

[2] The CCl_4 used in the 3:1 methyl formate-carbon tetrachloride mixture was not distilled. It was obtained from the General Chemical Co., was chemically pure and had a boiling range of 75–77° C. Its refractive index was determined as 1.4593.

The test insect, *Tribolium castaneum*, was reared on whole-wheat flour at a temperature of approximately 30° C. and a relative humidity of about 73 per cent. Approximately 50 adult beetles, from 2 to 6 weeks old and selected at random, were used in each subsample. The period of exposure was 2 hours at 30± 0.5° C. After fumigation the beetles were placed on whole-wheat flour in vials and kept at 30° C. and 73 per cent relative humidity. Death on the seventh day after fumigation was the criterion of mortality.

The apparatus used in this investigation is a modification of that described by Grayson & Swank (1941). The fumigation chamber (Fig. 1) consisted of a pyrex boiling flask (A) of approximately 5.5 liters capacity, closed with a ground-glass plate (B). Stopcock grease was used to give an air-tight seal. The ground-glass plate had a hole in which was inserted a one-holed rubber stopper (C). A tube (D) with a ground-glass stopcock was inserted through the hole in the stopper. The tube

reached the bottom of the flask and was used to break the ampule (E) containing the fumigant. The cardboard paddle (F) and the cage (G) containing the test insects were suspended with copper wire from the stopcock tube as shown in the diagram. Both the rubber stopper and the cardboard paddle were coated with shellac.

The ampules, also known as *Victor Myer Bulbs*, were blown from soft glass tubing. Their preparation is described by Grayson & Swank (1941). Breaking the ampule in the flask required some manipulation of the stopcock tube. With very volatile gases, such as methyl bromide, it was necessary only to break the neck of the ampule to release the fumigant in the flask. Less volatile materials, such as carbon tetrachloride and ethylene dichloride, however, diffuse too slowly through the capillary neck and consequently it was necessary to break the bulb itself. This was greatly facilitated by special treatment of the rubber stopper. A tube of slightly less diameter than the stopcock tube was inserted in the hole of the stopper. The tube and stopper were then heated to 150° C. for 20 minutes. This treatment made the stopper pliable and molded it to the tube. Then, after the tube was removed, the hole was moistened with glycerine and the stopcock tube was inserted. An air-tight fit was thus obtained which still allowed free movement of the tube through the stopper.

In making the tests the insects were placed in the cage and a partial vacuum was drawn with a filter pump. The ampule was then broken by pressure from the stopcock tube and after the liquid had vaporized the flask was returned to atmospheric pressure. The paddle was flipped back and forth by shaking the flask to insure thorough mixing of the gas in the flask.

The check insects received exactly the same treatment as those fumigated except that no fumigant was released in the flask. Fifty check insects were used to about 600 to 800 fumigated, but when only 2 out of 1153 died the number of checks were reduced.

Since the mixtures were prepared on a toxicity basis and not on a weight or volume basis the gases were first tested separately and the median lethal concentration of each was determined. Using these concentrations, carbon tetrachloride was mixed with each of the other gases in the proportions of 1:1, 1:3 and 3:1. Thus a 1:1 mixture contained the ingredients in the proportion of their median lethal concentrations and a 1:3 or 3:1 mixture con-

Table 2.—Toxicity of fumigants to *Tribolium castaneum* (Herbst); temperature, 30°C.; exposure period, 2 hours.

Fumigant	Number of Insects	Concentration, in mg. per Liter, Required to Kill— 50 Per Cent	99 Per Cent
Methyl bromide	2851	14.0	17.5
Methyl formate	2949	28.0	43.4
Ethylene dichloride	2070	95.5	149.5
Carbon tetrachloride	2996	105.5	209.1

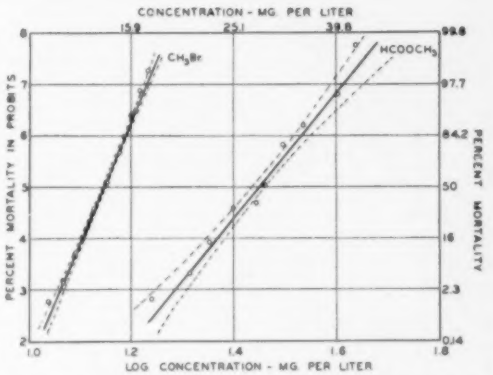

FIG. 2.—Toxicity of methyl bromide and methyl formate to *Tribolium castaneum*.

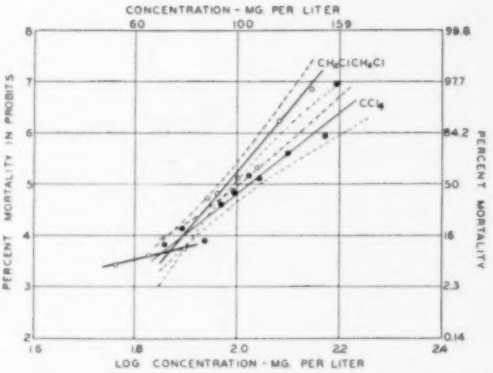

FIG. 3.—Toxicity of ethylene dichloride and carbon tetrachloride to *Tribolium castaneum*.

tained the ingredients in the proportion of 3 times the median lethal concentration of one to the median lethal concentration of the other. In any mixture the second figure in the ratio refers to the amount of carbon tetrachloride.

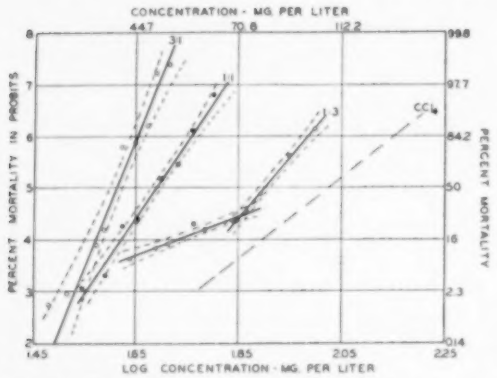

FIG. 4.—Toxicity of methyl-bromide-carbon tetrachloride mixtures to *Tribolium castaneum*.

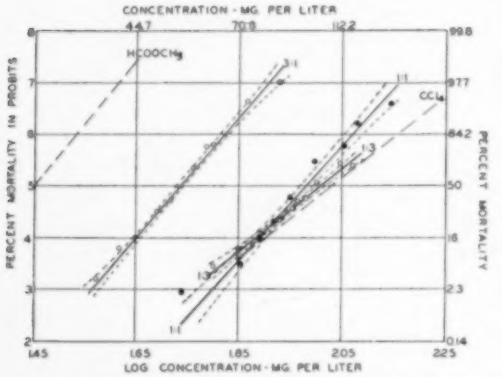

FIG. 5.—Toxicity of methyl formate-carbon tetrachloride mixtures to *Tribolium castaneum*.

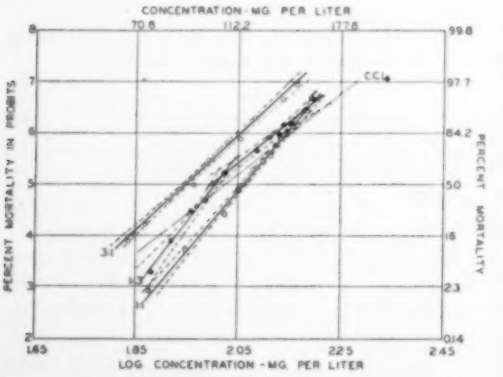

FIG. 6.—Toxicity of ethylene dichloride-carbon tetrachloride mixtures to *Tribolium castaneum*.

The data obtained from these experiments were plotted and analyzed statistically according to the method of Bliss (1935). The chi-square test was applied to the data and the limits of error for each regression line were calculated.

RESULTS.—The dosage-mortality curves for methyl formate, methyl bromide, ethylene dichloride and carbon tetrachloride are shown in figures 2 and 3. The concentrations of each calculated to kill 50 per cent and 99 per cent of the beetles are given in table 2.

Table 3.—Toxicity of fumigant mixtures to *Tribolium castaneum* (Herbst); temperature, 30°C.; exposure period, 2 hours.

Mixture	Number of Insects	Concentration, in mg. per Liter, Required to Kill— 50 Per Cent	99 Per Cent
Methyl bromide-carbon tetrachloride	1:1[1] 3295	49.1	70.3
	1:3 1606	79.5	124.2
	3:1 2496	41.0	50.7
Methyl formate-carbon tetrachloride	1:1 2745	94.7	153.5
	1:3 2984	101.3	198.8
	3:1 2488	54.0	85.4
Ethylene dichloride-carbon tetrachloride	1:1 3380	114.7	180.1
	1:3 2206	99.3	193.9
	1:3 1617	101.3	—
	3:1 3518	88.5	157.4

[1] A 1:1 mixture contained the ingredients in the proportion of their median lethal concentrations; a 1:3 or 3:1 mixture contained the ingredients in the proportion of 3 times the median lethal concentration of one to the median lethal concentration of the other. The second figure in the ratio refers to the amount of carbon tetrachloride.

The chi-square test, when applied to the carbon tetrachloride curve, indicated that considerably more variation occurred than would be expected from random sampling of a homogeneous population. Heterogeneity was also shown in the methyl formate and ethylene dichloride curves. The latter curve had a break near the lower end and that part below the break was not calculated. The data for the methyl bromide curve, when analyzed by the chi-square test, strongly indicated that these data are homogeneous.

The dosage-mortality curves for methyl bromide, methyl formate and ethylene dichloride in combination with carbon tetrachloride are shown in figures 4, 5 and 6. The calculated carbon tetrachloride curve is included in each figure for reference. The concentrations of each mixture calculated to kill 50 per cent and 99 per cent of the beetles are given in table 3.

The chi-square test was applied to the data for the mixtures and only in the 1:1

and 3:1 methyl bromide-carbon tetrachloride and 1:1 methyl formate-carbon tetrachloride curves was heterogeneity shown.

Antagonism was shown to be present in the 1:1 and 1:3 methyl formate-carbon tetrachloride and 1:1 and 1:3 ethylene dichloride-carbon tetrachloride mixtures.

The number of check insects used during the course of the investigation was 2845. Of this number, 12 or 0.4 per cent, failed to live.

DISCUSSION.—The stock cultures from which the test insects were obtained were started from a wild population. As the first generation of adults reared from the egg stage under controlled conditions was used in the early tests, it is likely that the data obtained therefrom may show more heterogeneity than that obtained after the population had become more stabilized. The curves for the gases alone were determined first and this may account for the better values for chi-square obtained for the mixtures.

During the latter part of the experiments tests were made to determine whether a change in resistance had occurred. Since the experiments were conducted over a period 4.5 months it was not unexpected that a change in population would occur. These tests indicated a significant decrease in resistance to ethylene dichloride. For carbon tetrachloride the principal change indicated was a decrease in the slope of the curve. There was no significant change in resistance to methyl formate.

The relative toxicities of the gases are shown in table 2. Methyl bromide and methyl formate are much more toxic than ethylene dichloride and carbon tetrachloride to *Tribolium castaneum*. Since ethylene dichloride is generally much more toxic than carbon tetrachloride to insects, it is interesting to note that under these conditions the two gases are about equal in toxicity to *T. castaneum* at the 50 per cent point. Figure 3 shows that the two curves cross at probit 4.0 (16 per cent mortality) and that their zones of error overlap up to probit 4.8 (42 per cent mortality). This indicates that there is not a significant difference in their toxicities at concentrations killing less than 42 per cent. Shepard, Lindgren & Thomas (1937) present data indicating that the toxicity of ethylene dichloride is affected much less by changes in temperature than is the toxicity of carbon tetrachloride. Increasing the temperature from 25° C. to 30° C. decreased the median lethal concentration of carbon tetrachloride from 185 to 125 mg. per liter for *T. confusum* at 5 hours exposure. Under the same conditions the median lethal concentration of ethylene dichloride was increased from 38 to 39 mg. per liter. This phenomenon may account, at least in part, for the two gases being nearly equal in toxicity to *T. castaneum* at 30° C. and 2 hours exposure. The shortened exposure period may also have been a factor.

Bliss (1939) recognizes three types of joint action: (1) *independent joint action*, in which the two components act independently of each other; (2) *similar joint action*, in which the two components produce similar but independent effects, and one component may be substituted for the other at constant ratio without affecting the toxicity of the mixtures; (3) *synergistic action*, in which one component synergizes or antagonizes the other.

Finney (1942) considers Bliss' representation of synertistic action to be inadequate and to have no logical relationship with the simpler concept of similar action. He tentatively suggests a generalization of the formula for similar action in which synergism is indicated by a positive value, antagonism by a negative value and similar action by a zero value. In the examples given, the slopes of the components of each mixture are approximately the same. Some modification is necessary before this formula can be applied to data in which the original components have different slopes. Another factor that needs consideration is the possibility of a change in resistance of the test insect occurring during the course of the investigation.

Bliss' method for the demonstration of synergistic action requires a series of dosage-mortality curves for various proportions of the ingredients and two practical objections can be pointed out. First, different proportions of the same two gases may produce different types of joint action and, second, obtaining and calculating the data for a series of dosage-mortality curves is a time-consuming task. In these experiments more than one type of joint action is indicated. Gunderson (1940) found that a low sublethal concentration of ether combined with the median lethal

concentration of ethyl acetate produced synergism with *Tribolium confusum*, but as the proportion of ether was increased the toxicity was reduced until probable antagonism was shown.

In certain cases considerable information may be secured on the type of joint action exhibited by a mixture from the position of its dosage-mortality curve with respect to the position of the curves of its components. A mixture may definitely be said to exhibit antagonism under the following conditions: first, if there is not a significant difference between the curve of the mixture and the curve of the less toxic ingredient; and second, if the curve of the mixture falls below the curve of the less toxic ingredient. In the first case, a certain amount of the less toxic ingredient alone produces a mortality as great as the same amount of the mixture; and, in the second case, a certain amount of the less toxic ingredient produces a mortality greater than the same amount of the mixture. Similarly, a mixture exhibits synergism if there is not a significant difference between its curve and the curve of the more toxic ingredient or if its curve falls above the curve of the more toxic ingredient. Thus, in these experiments, antagonism occurred in the 1:1 and 1:3 methyl formate-carbon tetrachloride and 1:1 and 1:3 ethylene dichloride-carbon tetrachloride mixtures. Furthermore, it appears that the general effect of mixing carbon tetrachloride with methyl bromide, methyl formate and ethylene dichloride is a decrease in toxicity to *Tribolium castaneum* since in a majority of the mixtures either antagonism occurred or a slight decrease in toxicity was indicated. In no case was there evidence of an increase in toxicity.

When using the position of the curves to determine if synergism or antagonism is exhibited by a mixture, any change in population that may have occurred must be taken into account. In these experiments a decrease in resistance is known to have taken place with ethylene dichloride. In addition, the toxicities of ethylene dichloride and carbon tetrachloride are so nearly equal that no conclusions can be drawn regarding the type of joint action exhibited by their mixtures as long as their curves fall between the curves of the two components. Thus, while synergism is indicated by the position of the 3:1 ethylene dichloride-carbon tetrachloride curve, the position of the curve may have been due to the change in population and not to any synergistic action between the two gases. On the other hand, while definite antagonism is shown by the 1:1 and 1:3 mixtures, it might have been more pronounced if the change in resistance had not occurred.

SUMMARY.—The dosage-mortality curves of methyl bromide, methyl formate ethylene dichloride and carbon tetrachloride for *Tribolium castaneum* (Herbst) at 30° C. and 2 hours exposure are presented. Methyl bromide and methyl formate are much more toxic to *T. castaneum* than ethylene dichloride and carbon tetrachloride. Ethylene dichloride and carbon tetrachloride are nearly equal in toxicity to *T. castaneum* at the 50 per cent point; the two curves cross at the point representing 16 per cent mortality and there is not a significant difference in toxicity with concentrations that kill less than 42 per cent.

Carbon tetrachloride was mixed with methyl bromide, methyl formate, and ethylene dichloride in equitoxic units in several proportions, and the dosage-mortality curves for these mixtures are presented.

Antagonism is said to be exhibited by a mixture if there is not a significant difference between its curve and the curve of the less toxic ingredient or if the curve of the mixture falls below the curve of the less toxic ingredient. Similarly, synergism is said to be exhibited by a mixture if there is not a significant difference between its curve and the curve of the more toxic ingredient or if its curve falls above the curve of the more toxic ingredient.

Using the above criteria, antagonism is shown to be present in the 1:1 and 1:3 methyl formate-carbon tetrachloride and 1:1 and 1:3 ethylene dichloride-carbon tetrachloride mixtures.

In general, a decrease in toxicity to *Tribolium castaneum* occurs when carbon tetrachloride is mixed with methyl bromide, methyl formate or ethylene dichloride. In no case is there evidence of an increase in toxicity, while in the majority of cases there is definite antagonism or a slight decrease in toxicity is indicated.

For certain theoretical and practical reasons pointed out by Finney (1942) and the writer, the method described by Bliss (1939) for the quantitative analysis of

synergistic action is believed to be of limited value in fumigation experiments. Finney (1942) tentatively suggests a generalization of the formula for similar action but some modification is necessary for its use with mixtures in which the curves of the components have different slopes.—12-2-42.

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Development of New Methyl Bromide Fumigation Schedules for Use Against Japanese Beetles

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Donohoe *et al.* (1940) reported the results from both small- and commercial-scale methyl bromide fumigations against the adult Japanese beetle, *Popillia japonica* Newm. A method for fumigation of produce in railway refrigerator cars was described which has been approved by the United States Department of Agriculture[2] for use in meeting the requirements of the Japanese beetle quarantine. In 1938 a dosage of 5 pounds of methyl bromide per car at a temperature of 70° F. or above, and in 1940 a dosage of 4 pounds at 80° F. or above, each for a 2-hour exposure period, were approved and put into commercial use.

During the seasons 1938 to 1942, inclusive, a total of 9948 cars of produce were fumigated at the above schedules as a means for freeing both the loads and the cars of live Japanese beetles. The commodities fumigated, in order of abundance, included white potatoes, sweet-potatoes, tomatoes, onion, cabbage, apples, snap beans, lima beans, turnips, and mixed loads.

The successful application of fumigation to refrigerator cars, however, has indicated the need for a broader range of treating schedules for these cars, as well as for the development of schedules that can be used in other types of enclosures. During the 1941 season Donohoe & Gaddis (1942) in eight experimental fumigations showed that the schedules applied to refrigerator cars were effective in refrigerator-type truck bodies. Donohoe in 1940, 1941, and 1942 and Donohoe & Kerbey in 1942 continued the earlier investigations. This paper presents the information that has been accumulated on new and revised schedules for fumigations and on the possibilities for application to various types of enclosures.

[1] During the 1942 season, Mr. George F. Kerbey, Division of Japanese Beetle Control, Bureau of Entomology and Plant Quarantine, assisted materially in the work performed.

[2] Administrative instructions issued in 1938 as B.E.P.Q. 475 and 480, and later incorporated in B.E.P.Q. 499, Administrative instructions to inspectors on the treatment of nursery products, fruits, vegetables, and soil, for the Japanese beetle, issued September 1939. The modified schedule, approved in 1940, is given in Supplement 2 to B.E.P.Q. 499.

The methods for the development and testing of new schedules discussed by Donohoe *et al.* (1940) were used with little change in subsequent work. To simplify ultimate commercial application, all schedules were based on a fixed 2-hour exposure period. Prospective new schedules were established by testing them in experimental fumigation vaults and, insofar as possible, in larger, commercial enclosures. Little attention was paid to the type or quantity of produce load. No evidence has been obtained of reduced effectiveness through the presence of a load of any of the fruits or vegetables requiring treatment. Although penetration of the fumigant into the packages no doubt occurs somewhat less rapidly than through the vault space, conversely, dissipation from the packages after the termination of the treatment occurs more slowly. The principal effect of the load is to reduce the actual volume of fumigable space and thereby to increase the concentration obtained over that calculated. For this reason and because of the practical obstacles to obtaining loads of produce for use in large-scale experimental tests, about 58 per cent involved empty enclosures.

All test beetles were collected by hand or net and were fumigated usually on the day of collection and always within 2 days. A few tests were made late in the season with lots showing high control mortality, but they are included in the records only in case of significant differences between control and test mortality. In the 84 experimental tests discussed below, control mortality based on the records for individual mortality percentages averaged 7.7 per cent. For all work in 1940 and subsequently, beetles were caged for testing in 1-pint cardboard cartons provided with screened tops and bottoms and with screened windows in the sides.

FUMIGATIONS IN EXPERIMENTAL VAULTS —Including 17 tests previously reported on by Donohoe *et al.* (1940), 49 experimental fumigations were run in portable fumigation boxes at 2-hour exposures and

with dosage or temperature requirements, or both, other than those for the two schedules already approved. The volumes of the vaults used were 100, 54, 50, 38 and 33 cubic feet. In all tests the methyl bromide was introduced as a liquid into an evaporating pan. An initial circulation period of 5 minutes after introduction of the fumigant was the rule, although this period was extended up to the full 2-hour exposure in special cases. Circulation was provided by various ventilating and desk-type fans.

The information from the vault fumigations was used as a basis for prospective new or altered schedules, which then were tested for efficiency in larger enclosures such as would be employed in commercial treating.

bodies can be regarded as suitable fumigation enclosures.

Circulation was provided for 5 minutes in all trucks. In refrigerator trucks this was accomplished by utilizing the cooling units fans operated by a gasoline "kicker" motor. For the van bodies an electric blower delivering from 120 to 250 cubic feet per minute was used. Methyl bromide was released into the blower air stream through a disk spray nozzle with a 2-mm. orifice.

In all tests mortality of the beetles was complete within 24 hours after treatment.

FUMIGATIONS UNDER DUCK COVER TREATED WITH ETHYL CELLULOSE.—Several fumigations were run under a 272-cubic-foot, frame-supported duck cover with lapped edges at the soil surface

Table 1.—Summary of fumigations at experimental schedules in various types of enclosures. Exposure period, 2 hours.

Dosage Pounds per 1000 Cu. Ft.	Vault		Refrigerator Truck Body		Van Truck Body		Duck Cover		Refrigerator Car		All		Min. Temp. Range With[1] 100% Mort. °F.	Max. Temp.[1] Range With Survivors °F.
	Tests	Total beetles	Tests	Total beetles	Tests	Total beetles	Tests	Total beetles	Tests	Total beetles	Tests	Total beetles		
0.50	10	22,670									10	22,670	93–93	93–95
0.75	9	23,055									9	23,055	83–82	80–80
1.00	13	54,977	8	8,464	1	934					22	64,375	76–77	74–74
1.20	2	1,340					4	6,508			6	7,848	77–77	
1.50			8	9,538	2	3,192			2	14,996	12	27,726	68–72	
1.60	2	1,073			1	768	5	6,443	2	11,778	10	20,062	72–72	
2.00	5	12,571									5	12,571	66–64	60–61
2.25	2	2,186									2	2,186	62–58	
2.40									2	2,088	2	2,088	51–53	
2.50	2	2,882									2	2,882	59–59	57–53
3.00	3	4,350									3	4,350	53–52	53–50
3.25	1	1,307									1	1,307		53–48
Total	49	126,411	16	18,002	4	4,894	9	12,951	6	28,862	84	191,120		

[1] In this table the temperature range refers to the temperatures at the beginning and end of a fumigation.

FUMIGATIONS IN REFRIGERATOR AND VAN-TYPE TRUCK BODIES.—Since the work of Donohoe & Gaddis (1942) had proved the efficiency of refrigerator trucks at established schedules, a number of these trucks were tested at prospective schedules. Work likewise was carried out with closed van-type trucks, which may or may not have tightly fitting doors and be maintained in sound condition, whereas refrigerator trucks must be tightly maintained to serve as efficient refrigerating units.

Following a suggestion made by J. H. Harman, associate entomologist in charge of Japanese beetle control for the State of New Jersey, masking tape was tried for closing body breaks, door cracks, and other openings in truck bodies. It was found that, with careful inspection and taping of all visible openings, van-truck

weighted with dirt all around. The cover used was of 10-ounce duck with a double coat of ethyl cellulose on one side and a single coat on the other. The methyl bromide was introduced through a spray nozzle into the air stream of a portable electric blower delivering 120 cubic feet of free air per minute on a diagonal across the top of the enclosure. Mortality in all tests was complete within 24 hours after treatment.

REFRIGERATOR CAR FUMIGATIONS.—Four of the 1939 refrigerator-car fumigations were at schedules which apply in the present study. Only two additional car tests have been made, both with complete mortality

SUMMARY OF ALL TESTS.—All the fumigations discussed above are summarized in table 1. Complete mortality of test beetles occurred in all fumigations of commercial

enclosures. The only survivors were in vault fumigations, which in the main were exploratory and preceded the others.

DOSAGE SCHEDULES FOR COMMERCIAL USE.—The data in table 1 demonstrate that the old commercial schedules of 2 and 1.6 pounds (5 and 4 pounds per refrigerator car) are effective below the minimum temperatures specified when first released for use, and also that several new schedules are permissible.

Schedules for refrigerator-car dosages are set up in even 1-pound units for simplification of required equipment. The dosages are based on an average car volume of 2500 cubic feet. On this basis they can be converted into pounds per 1000 cubic feet for use in other enclosures.

For all commercially applicable schedules an allowance is made for leakage by establishing the minimum temperature at a point somewhat above that required for tight enclosures. With the prime requirement for even pound dosages for refrigerator cars, the temperature minima for the schedules have followed no fixed pattern. In the main, they have been established tentatively on the basis of prior results and then tested for efficiency. Thus they range from about 4 to more than 10 Fahrenheit degrees above the minima for tight enclosures. Considering the above requirements, the evidence justifies a new series of fumigation schedules for use in treatment of produce to free it from live Japanese beetles, as shown in table 2.

These new schedules are applicable not only to refrigerator cars and fumigation rooms, but also to refrigerator and van-type truck bodies and enclosures covered with gas-proofed duck. With the increase in the types of enclosures permissible for use, methyl bromide fumigation probably will become an increasingly important treatment for meeting Japanese beetle quarantine requirements. The modifications of existing schedules should, in addition, effect some reductions in fumigation costs and in the possibility of injury to certain fruits and vegetables.

Table 2.—Fumigation schedules for use in produce treatments against the Japanese beetle. Exposure period, 2 hours.

Minimum Temperature of Load and Enclosure, °F.	Dosage	
	Pounds per Refrigerator Car	Equivalent in Pounds per 1000 Cu. Ft.
60	6	2.4
68	5	2.0
77	4	1.6
86	3	1.2
95	2	0.8

SUMMARY.—Experimental fumigations in portable chambers, refrigerator and van-type truck bodies, a gas-proofed duck cover, and refrigerator cars have demonstrated the practicability of five fumigation schedules within the minimum temperature range from 60° to 95° F. These are for use in treatments to free fresh produce from live Japanese beetles in compliance with quarantine regulations. Two of the schedules are modifications of existing ones and three are new.—1-15-42

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Because the satin moth is considered no longer of economic importance in Oregon the Director of Agriculture of that State on March 19, 1943, revoked the quarantines pertaining to the pest in Oregon as well as other States.

Georgia's quarantine on the sweetpotato weevil as revised March 15, 1943, makes modifications as to regulated areas in the infested States.

Relation of Chemical Constitution of Some N-Heterocyclic Compounds to Toxicity to *Tetranychus telarius* (L.)[1,2]

H. L. King and D. E. H. Frear, *Pennsylvania Agricultural Experiment Station, State College*[3]

In the search for new organic insecticides, the highly toxic properties of nicotine have stimulated a number of investigations of the insectidal possibilities of other N-heterocyclic compounds. Several workers have studied the properties of pyrrole and its derivatives, some have studied the various dipyridyls, and others have investigated the derivatives of pyridine and quinoline. The last-mentioned group of compounds has been tested by a number of different methods and on a number of different insects. Richardson & Smith (1923), in an investigation of a large number of organic compounds, sprayed the materials on nasturtium plants infested with bean aphids and considered their results as an indication of contact toxicity. Tattersfield & Gimingham (1927) sprayed aphids with certain of these compounds and confined the aphids in closed containers with leaves of their food plants. They considered their results from the standpoint of combined contact and fumigant action. Bushland (1940) mixed the test compounds with the culture medium in which he reared larvae of the screwworm, *Cochliomyia americana* C. & P., and in this manner measured the combined contact action and stomach action of the materials. Shaw & Steer (1938) investigated the ovicidal properties of certain quinoline derivatives, using eggs of *Orgyia antiqua* L., while Smith (1940) studied the toxicity of a group of related compounds to eggs of *Lygaeus kalmii* Stål.

The purpose of the investigations reported in this paper[4] was to measure the relative toxicity of pyridine and a series of compounds related to pyridine as contact sprays on the greenhouse red spider, *Tetranychus telarius* (L.); to attempt to establish some relationships between chemical structure and toxicity to red spider; and to compare these relationships with those established by the above investigators in their work with various insects.

Materials.—The choice of the greenhouse red spider, or spider mite, as a test animal was prompted by several considerations. It is an easily reared organisn, of economic importance, and is related to insects, but since it belongs to another class, it cannot be assumed that it would react to toxicants in the same manner as the insects which have been investigated by the workers mentioned above. Furthermore, it has sucking mouth-parts, thus eliminating to a great extent the possibility of stomach poisoning, and it is not particularly susceptible to fumigants. In this work the sprayed plants were kept in a well ventilated position, minimizing the possibility of fumigant action, so that the results represent contact action only.

The compounds tested in this work are listed in table 1. The chemicals used were all pure with the exception of β-picoline, which was an 85 per cent solution. Acridine and 2-amino-pyridine were crystalline preparations. All others were liquids. For testing, the compounds were dissolved in a mixture of equal parts of acetone and water. Each compound was in true solution at the time of spraying.

Table 1.—Degree of control of red spider secured by a 1.0% solution of various N-heterocyclic compounds.

Compound	Boiling Point (Degrees C.)	Per Cent Control of Red Spider
Pyridine	115.3	0.6
α-picoline	128	0.6
β-picoline	143.5	0.0
2-6-lutidine	143	1.3
2-me-6-amino-pyridine	208–9	39.6
2-amino-pyridine	204	41.2
Quinoline	237.7	65.1
Acridine	346	100.0

The sprays were applied from an atomizer-type air-brush, operated by a *DeVilbiss* air compressor, at a constant spray-

[1] Authorized for publication on November 9, 1942 as Paper No. 1140 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

[2] Eastern Branch Program, New York, November 1942.

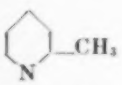
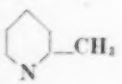
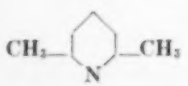
[3] Reilly Research Fellow and Assistant Professor of Agricultural and Biological Chemistry, respectively. This work was supported in part by a grant from the Reilly Tar and Chemical Corporation, of Indianapolis, Indiana, and was carried out in the Department of Agricultural and Biological Chemistry in cooperation with the Department of Zoology and Entomology, and at the suggestion and with the cooperation of the Research Division of the Reilly Tar and Chemical Corporation.

[4] Other papers are to follow.

ing pressure of sixteen pounds per square inch, and were sprayed into a wooden chamber, 30×39×35 inches, equipped with an exhaust fan at the back and a turntable at the rear center.

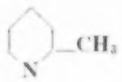
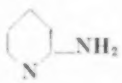
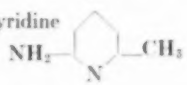
PROCEDURE.—Garden beans of the Black Wax Pencil Pod variety were grown in greenhouse flats until the seed-leaves were well developed, and were then transplanted into 2-inch pots. One day after transplanting, the plants were innoculated with mites by laying heavily infested leaves from the culture-bed on the plants to be innoculated. Twenty-four hours after innoculation, an infested plant was placed on the turntable of the spray-chamber and the spray applied from a distance of 30 inches, for 30 seconds. During this time the turntable and plant made approximately eight revolutions. After spraying, the plant was set aside for 24 hours, at the end of which time the numbers of live and dead adult mites were counted, using a 7-power binocular microscope. Per cent control was calculated by Abbott's formula, each day's results being corrected against a series of blank sprays containing equal parts of acetone and water. The survival of mites on the plants sprayed with the blank sprays was consistently above 90 per cent. Throughout the experiment, the average infestation per plant was well over a hundred mites.

Table 2.—Effect of the addition of methyl groups to the pyridine nucleus on the degree of control of red spider.

COMPOUND	STRUCTURE	PER CENT CONTROL OF RED SPIDER BY A 5 PER CENT SPRAY
Pyridine		1.5
α-picoline		0.7
β-picoline		2.2
2-6-lutidine		1.6

EXPERIMENTAL DESIGN AND RESULTS.—As the experiment was originally set up, each compound was tested at a concentration of 1 per cent, using from four to seven replicates, depending on the degree of agreement among them. The results of this series of sprays are given in table 1. It will be seen from the table that, at this concentration, the control given by pyridine, the picolines and lutidine was too low to demonstrate differences among them. Accordingly, these compounds were retested at a concentration of 5 per cent, using seven replicates. (Table 2.)

Table 3.—Comparison of the effect of the addition of amino and methyl groups to the pyridine nucleus on the degree of control of red spider.

COMPOUND	STRUCTURE	PER CENT CONTROL OF RED SPIDER BY A 1 PER CENT SPRAY
Pyridine		0.6
α-picoline		0.6
2-amino-pyridine		41.2
2-me-6-amino-pyridine		39.6

DISCUSSION.—The compounds tested fall naturally into three series. The first of these is represented by table 2. Here is found an indication that the addition of one or two methyl groups does not increase the toxic action of the pyridine nucleus. However, it should be noted that even at a concentration of 5 per cent, these compounds did not give any significant degree of control. For this reason comparisons within the series may not be valid. Richardson & Smith (1923), experimenting with aphids, found picoline more toxic than pyridine, while Tattersfield & Gimingham (1927) found pyridine, picoline and lutidine to increase in toxicity in the order mentioned.

The second series of compounds is represented by table 3. Here it will be seen at once that the addition of the amino group to the α-position of the pyridine nucleus markedly enhances the acaricidal action

of that nucleus. The addition of a methyl group in the α-position, either to pyridine or to α'-amino-pyridine adds nothing to the toxicity of the original molecule. As mentioned above, a comparison of pyridine and picoline may be questioned because of the slight degree of control given by either. The comparison between 2-amino-pyridine and 2-me-6-amino-pyridine, however, is not subject to such criticism, and is taken as a definite indication that the methyl group does not add to the toxicity of the molecule.

Table 4.—Effect of the addition of benzene rings to the pyridine nucleus on the degree of control of red spider.

COMPOUND	STRUCTURE	PER CENT CONTROL OF RED SPIDER BY A 1 PER CENT SPRAY
Pyridine		0.6
Quinoline		65.1
Acridine		100.0

The third series of compounds is listed in table 4 and illustrates the remarkable increase in toxicity that occurs when one or two benzene rings are condensed with the pyridine nucleus. In the limited series studied, toxicity was almost directly proportional to the number of benzene rings added. In connection with this series, it may be mentioned that Smith (1940), as well as Richardson & Smith (1923), found quinoline more toxic than pyridine, while Tattersfield & Gimingham (1927) found pyridine, quinoline and acridine to increase in toxicity in the order mentioned.

The increasing order of toxicity of all the compounds studied is as follows: pyridine = α-picoline = β-picoline = 2-6-lutidine < 2-me-6-amino-pyridine = 2-amino-pyridine < quinoline < acridine. In so far as the same compounds were used, this order agrees in a general way with the order of toxicity given by Tattersfield & Gimingham and by Richardson & Smith. However, the authors mentioned, working with aphids, were able to demonstrate differences among the lower members of the series, indicating that the methyl groups added to the toxicity of the parent molecule. In the present investigation with greenhouse red spider, this was not the case, indications being found that the methyl group did not add to the toxicity of the molecule to this organism.

The boiling points of the compounds used are listed in table 1. It will be noted that the order of toxicity is approximately the same as the order of increasing boiling points.

SUMMARY.—Eight N-heterocyclic compounds related to pyridine were tested as contact acaricides on the common red spider, *Tetranychus telarius* (L.).

Results of these tests indicated that

(a) the addition of one or two methyl groups did not increase the toxicity of the pyridine nucleus.

(b) the addition of an amino group in the α-position markedly increased the toxicity of the molecule to the mite.

(c) the condensation of the pyridine nucleus with a benzene ring to form quinoline resulted in increased toxicity, while condensation with two benzene rings to form acridine further increased the toxic action toward the mites.

The increasing order of toxicity of all the compounds tested is as follows: pyridine = α-picoline = β-picoline = 2-6-lutidine < 2-me-6-amino-pyridine = 2-amino-pyridine < quinoline < acridine.

The increasing order of toxicity was found to be nearly the same as the increasing order of boiling points.—12-2-42.

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The Effect of Diluents on the Toxicity of Pure Ground Derris Root in Dusts[1]

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The effect of diluents on the performance of ground derris and cube has been considered by several workers. Huckett (1934) used talc, clay, tobacco dust and hydrated lime with derris on cabbage worms. There was little difference in percentage of uninjured heads following application of the first three, but hydrated lime seemed to be definitely inferior. Walker & Anderson (1934) stated, of tests on cabbage worms " . . . of the carriers used, talc gave the best control, closely followed by gypsum and Inert C. . . . The newly made lime dust, flour, and tobacco dusts ranked intermediate, while the old lime and zinc sulphate-lime gave the poorest results." On the harlequin bug, gypsum and talc were the more effective, and flour, Inert C and lime were much less effective. In a second report (Walker & Anderson 1936) gypsum, sulfur 1 part and talc 9 parts, talc (mixed one year previously), talc (mixed fresh), Inert C, tobacco dust and bentonite, all with 0.5 per cent rotenone in ground derris root, were effective in that order. Gypsum, sulfur-talc, and old talc were in one group as to effectiveness; talc (freshly mixed), Inert C and tobacco dust intermediate; and bentonite least effective.

Howard *et al.* (1935), tested diluents for derris on the Mexican bean beetle. "Of six carriers and combinations of carriers, comprising talc, tobacco dust, infusorial earth, ground marc (extracted pyrethrum flowers), inert clay, and hydrated lime, talc in general proved to be the best. . . . Hydrated lime in some instances appeared to reduce toxicity and should not be recommended. The selection of the best carrier for use in dust mixtures will require more experimentation." Allen & Brooks (1940) studied the effect of alkaline diluents on rotenone-bearing roots. After 7 days in damp storage the toxicity of derris was reduced materially as measured by tests on house flies. Addition of sulfur prevented this deterioration.

Walker & Anderson (1939), working on pea aphids, compared cube dusts with walnut-shell flour, talc and clay as diluents. The survival of aphids was: Walnut-shell flour 7.1 per cent, talc 9.5 per cent and clay 26.8 per cent of the population on untreated plants.

Wilson *et al.* (1941) studied the effect of electrostatic charge on toxicity of rotenone-bearing dusts to pea aphids. Fibrous talc developed a low charge and was less effective than flaky talcs which produced a high electrostatic charge. Further, the addition of soybean oil increased both charge and toxicity. Pyrophyllite, flaky talc, calcium carbonate and gypsum were much more effective as diluents than fibrous talc. It is of interest to note that in many cases the high-charge diluents produced better mortality with 0.1 per cent rotenone and 2 per cent soybean oil than with 0.75 per cent rotenone and the same amount of oil.

Wilson & Janes (1942 a) reported further on electrostatic charge effects. They stated: "A large number of clay and talc diluents have been studied at the University of Wisconsin and sufficient data has now been obtained to show that clay diluents are not compatible with rotenone." Materials from 22 of the 38 talc and pyrophyllite deposits were tested and one pyrophyllite and five talcs found superior to all other samples for use in rotenone-bearing dusts. A series of tests comparing rotenone content from 0.1 per cent to 0.75 per cent showed that 0.5 per cent was more toxic than any other concentration. They also stated that humidity was more important than temperature in its effect on control and that high velocity dusters and proper nozzle adjustment were necessary for best results. Oils continued to have a good effect, and mineral oils were more satisfactory than vegetable oils if dusts were stored long before use.

Later (1942 b) Wilson & Janes listed by source and manufacturer the superior diluents. Twenty-six materials were tested in dosage series. Of these six were superior: A pyrophyllite and a calcium carbonate were best, and three talcs and a soapstone slightly less satisfactory. They called attention to variations in products of the same company and the need for stand-

[1] Eastern Branch Program, New York, November, 1942.

ardizing materials. Cube and derris powders developed a negative charge and the diluents a positive charge. The mixture of ground root with mineral diluent showed a reduced charge and when equal amounts of the two were used the charge sometimes dropped to zero. Walnut-shell flour and lignin dust produced moderately high charges and were highly effective diluents. The best mineral diluents were more abrasive to machinery than the less effective materials.

Campau, *et al.* (1942) reported on a long series of tests with oils and other adjuvants for rotenone-bearing dusts. Some materials showed promise for use with extremely low concentrations of rotenone.

Brannon (1942) reported on field tests to control the Mexican bean beetle, using various diluents with 0.5 per cent rotenone in dusts. Rain fell after each treatment, reducing the effectiveness. The order of effectiveness was (1) talc, (2) sulfur, (3) pyrophyllite, (4) redwood-bark flour, (5) walnut-shell flour, (6) diatomaceous earth, (7) infusorial earth, (8) clay and (9) tobacco dust. The last two were practically ineffective. Tenacity may have been a factor in the superior performance of some diluents. Commercial dusts tested in 1940 varied in effectiveness, probably because of the diluent used.

Gray & Schuh (1940) reported no differences between diatomaceous earth and talc in rotenone-bearing dusts to control pea aphids. Fisher & Shull (1942) found no significant difference between sulfur, diatomaceous earth and talc as diluents for cube in tests on legume bugs.

These reports show in general that the diluent used with ground derris or cube roots may have a chemical or physical effect on the toxic materials in the roots. The deleterious chemical effect of alkaline materials appears to be well established. The possible physical effects are less well known. The work of Wilson and his associates has established a relationship between electrostatic charge and toxicity.

It is of interest to note that Huckett (1940) found definite differences between diluents used with pyrethrum. Moreover, Hervey & Pearce (1942) reported similar results following use of lead arsenate dusts with different diluents.

PURPOSE OF THIS INVESTIGATION.—This study was made as a part of the work on diluents for dusts already in progress. The purpose of the phase reported here was to establish both in the laboratory and in the field the relationship between diluents commonly used for rotenone-bearing dusts.

LABORATORY TESTS.—*Aphis rumicis* Linn. breeding on nasturtiums growing in the greenhouse were used in all tests. Infested leaves were removed to the laboratory, exposed to the dust, and kept for 24 hours in a constant temperature room (75° F., 75 per cent relative humidity). Counts were made of the insects dead and alive. The dust exposure was made in the settling tower described by Heuberger & Turner (1942). A suitable charge of dust for the purpose was introduced and dusted at 20 pounds air pressure. The time of exposure was six minutes and 45 seconds, which allowed complete settling.

All dust samples were mixed from the same lot of pure ground derris root (4 per cent rotenone content), using a cocktail-shaker mixer devised by Heuberger.

All of the tests were made in dosage series. Replicate tests were made on different days, all materials under comparison being used on each day.

FIELD TESTS.—In general field tests were made on small plots of suitable size with treatments randomized in blocks. Small plunger dusters were used in some tests, rotary hand dusters in others. Applications were made at the approximate time for commercial treatment of the crops used.

Two types of results were obtained. Where possible, accurate counts were made of the number of insects surviving treatment. When this was not possible, a rating system described by Horsfall (1942) was applied. In brief, this system was based on an estimate of the amount of feeding done by the insects. Leaves or plants not injured were ranked as "0," those with 1 to 25 per cent injury, as "1"; 26 to 50 per cent, as "2"; 51 to 75 per cent as "3," and 76 per cent to total destruction as "4." Thus, if 10 plants in a plot were rated, the maximum score would be 40. If each of the plants rated 2, the total would be 20 and the damage 50 per cent.

All graphs have been plotted on the logarithmic-probability grid.

RESULTS OF LABORATORY TESTS.—*Diluents alone.* One sample of clay and one of pyrophyllite were tested on aphids. The results of three tests repeated on each of

Table 1.—Derris root undiluted and diluted with three diluents.

Diluent	Per Cent Rote-none	Amount of Pure Ground Derris in 3 sq. in. Deposit	No. Dead	No. Alive	Per Cent Dead
None	.25[1]	.0080	267	337	44.2
	.50[1]	.0135	594	241	71.1
	1.00[1]	.0240	729	218	78.0
	2.00[1]	.0420	809	115	87.6
Pyrophyllite	.25	.0050	630	171	78.6
	.50	.0100	518	130	79.8
	1.00	.0200	665	91	87.9
	2.00	.0400	534	104	83.7
Clay	.25	.0050	124	253	32.9
	.50	.0100	264	329	44.5
	1.00	.0200	192	188	50.5
	2.00	.0400	219	130	62.8
Talc	.25	.0050	177	249	41.5
	.50	.0100	208	229	47.6
	1.00	.0200	264	224	54.1
	2.00	.0400	230	78	74.6
No treatment	none				14.7

[1] Amount of pure ground derris to equal amounts in mixed dusts.

two days showed a mortality of 14.4 per cent for clay, 10.3 per cent for pyrophyllite and 11.0 per cent for aphids not treated. This indicated no toxicity for pyrophyllite and little or none for clay.

Diluents with ground derris root. In order to determine the magnitude of differences between diluents, a series of tests was made using undiluted ground derris root in comparison with the same material mixed with diluents. This was possible using the settling tower method. The ground derris root contained 4 per cent rotenone,

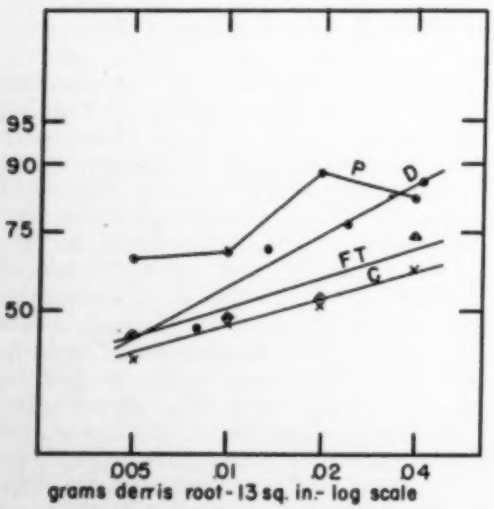

FIG. 1.—Dosage-response curves for derris without diluent (D), and with pyrophyllite (P), fibrous talc (FT) and clay (C) using aphids in laboratory tests.

therefore 1 gram of 1 per cent dust contained 0.25 gram of pure ground root. The charge of 0.25-gram of pure ground root was compared with a charge of 1 gram of mixed dust. Similar charges were used for the entire dosage series. This technique

Table 2.—Derris root mixed with three diluents.

Diluents	Per Cent Rote-none	No. Dead	No. Alive	Per Cent Dead
Pyrophyllite	0.125	219	80	73.2
	0.25	255	90	73.9
	0.5	206	37	84.8
	1.0	213	52	80.4
Talc (Flaky)	0.125	160	159	50.1
	0.25	130	118	52.4
	0.5	103	94	52.8
	1.0	226	78	74.3
Slate Dust	0.125	89	121	42.4
	0.25	137	167	45.0
	0.5	254	119	68.1
	1.0	241	84	74.1

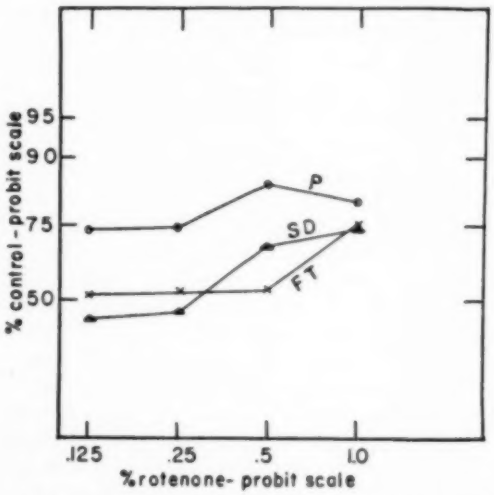

FIG. 2.—Dosage-response curves for derris with pyrophyllite (P), flaky talc (FT) and slate dust (SD) using aphids in laboratory tests.

produced results for a dosage-response series for pure ground derris root and for three diluents: (1) A clay, (2) a pyrophyllite, and (3) a fibrous talc. Five replicate tests were made using the pyrophyllite and three with the other diluents. The results are summarized in table 1 and shown graphically in figure 1. The curves for clay and fibrous talc have a different slope than the one for pure ground derris. Part of the difference may be due to differences

in coverage because of the larger bulk in the diluted dusts. The different slope could also mean a difference in mode of toxic action induced by the presence of the diluents. At best, neither clay nor fibrous talc increased the toxicity. Pyrophyllite definitely increased toxicity of the lower concentrations. There was no substantial difference between fibrous talc and clay.

In the second series of tests pyrophyllite was used as the standard, and a flaky talc and a slate dust compared with it. The results (three replicates) are given in summary in table 2 and in figure 2. The pyrophyllite was much more effective, especially at the lower concentrations. There appeared to be little difference between the slate dust and flaky talc.

It will be noted that the response curves for pyrophyllite in figures 1 and 2 and for slate dust and talc in figure 2 have not been drawn as straight lines. The divergence of individual points from the "mean," which in this case is the straight line, can indicate one of two things. Either the results are extremely variable and the divergence is simply an indication of this variability, or the divergence has a meaning. Certainly in the case of pyrophyllite the fact that in both series 0.5 per cent dust was more toxic than 1 per cent dust cannot be discarded as variation. There is less evidence in the case of slate dust and talc, but the results at least indicate that the response is not strictly ectilinear.

FIELD TESTS.—Since the laboratory tests had shown a considerable difference in effectiveness among common diluents, field tests were made. The advantages of using a series of concentrations were so great that this method was adopted. This made it necessary to reduce the number of diluents tested to a minimum on account of the large number of plots involved. The pyrophyllite, which showed the best laboratory performance, and the clay, which had been least effective, were chosen for this purpose.

Striped cucumber beetle.—It was necessary to make cage tests with cucumber beetles in order to obtain figures for mortality. Adults were collected in the field and placed in small cylindrical wire screen cages for dusting. The dust was applied with a small plunger duster directed at the open end of the cage. The dusted beetles were placed over potted squash plants. Mortality was observed at the end of 48 hours. The results were highly variable, probably because of injury to the beetles in the collecting and treating process. The results of the tests, involving three replicates for each concentration, are given in table 3, with response curves plotted in figure 3. The variation in results was too great to establish a numerical relationship, but certainly clay as a diluent was distinctly less toxic.

Table 3.—Cage tests with striped cucumber beetle.

DILUENT	PER CENT ROTENONE	NO. DEAD	NO. ALIVE	PER CENT DEAD
Pyrophyllite	0.125	17	15	53.1
	0.25	30	10	75.0
	0.5	42	2	95.5
	1.0	34	3	91.9
	2.0	52	0	100.0
Clay	0.25	14	25	35.9
	0.5	19	26	54.3
	1.0	22	12	64.7
	2.0	33	2	94.3

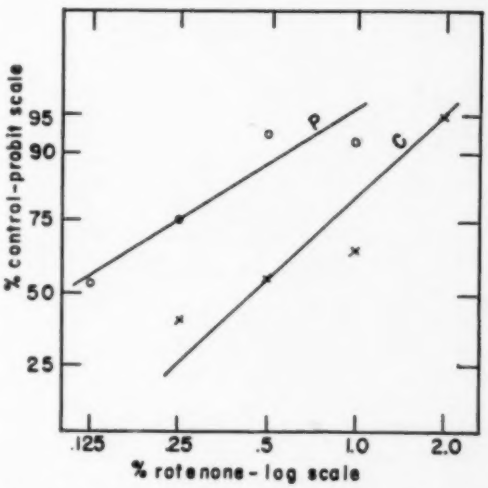

FIG. 3.—Dosage-response curves for derris with pyrophyllite (P) and clay (C) using striped cucumber beetles in cage tests.

Potato flea beetle.—Irish Cobbler potatoes were dusted with a series of concentrations of ground derris root with pyrophyllite and clay diluents. There were five replicates for each concentration, randomized in blocks. Dusting was done with a small plunger duster, using a conical cellu-

Table 4.—Control of potato flea beetle using ground derris with two diluents.

Diluent	Per Cent Rotenone	Per Cent Foliage not Damaged
Pyrophyllite	0.25	76.8
	0.5	82.6
	1.0	92.8
	1.5	93.3
	2.0	95.7
Clay	0.25	74.0
	0.5	68.0
	1.0	78.3
	2.0	86.0

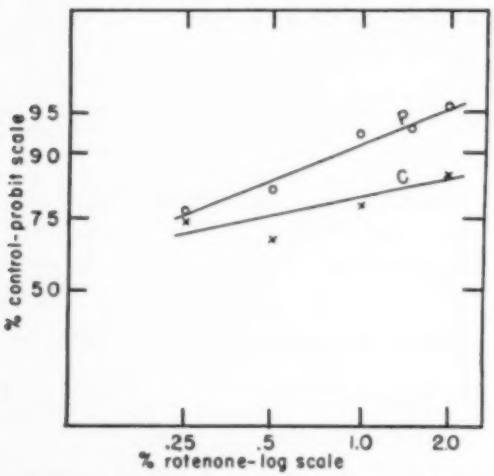

Fig. 4.—Dosage-response curves for derris with pyrophyllite (P) and clay (C) in controlling potato flea beetles. Control expressed as percentage of foliage not damaged.

lose acetate hood to confine the dust to the individual plants. Dates of dusting were May 24, June 4, 9, 18, 24 and 30. Results were taken by estimating the damage by flea beetles,[1] and are summarized in table 4 and figure 4. As in the laboratory and cage tests, a considerable difference existed between the two materials. In terms of dosage for equal control, 0.9 per cent rotenone with clay equalled 0.35 per cent with pyrophyllite at the 80 per cent level.

Mexican bean beetle.—Late beans, planted July 1, were used in this test. The plots were randomized in four blocks, each plot being a 40-foot row. A rotary hand duster was used in all tests, and delivered dust at the rate of 24 pounds to the acre. Dates of treatment were July 28 (for adults) and August 8 and 18 (for larvae). Samples for counts of surviving larvae were 10 plants taken at random from each plot. In addition to counting the larvae, an estimate of the damage to the foliage was made at the same time and on the same plants. A summary of the results is given in table 5 and in figure 5.

In terms of both kill of insects and protection of the foliage, pyrophyllite was much more effective. At the very least, 4 times as much rotenone was needed with clay to kill as many insects as with pyrophyllite. In terms of foliage protection 0.9

Table 5.—Control of Mexican bean beetles using ground derris with two diluents.

Diluent	Per cent Rotenone	No. Larvae	Per Cent Reduction in Larvae	Per Cent Foliage not Damaged
Pyrophyllite	0.0625	228	69.9	61.25
	0.125	96	88.6	76.25
	0.25	8	98.9	80.0
	0.5	2	99.3	86.25
	1.0	2	99.7	90.62
Clay	0.125	353	53.4	61.25
	0.25	227	70.0	71.25
	0.5	72	88.1	74.37
	1.0	21	97.2	81.25
	2.0	14	98.1	86.25
None		757		32.5

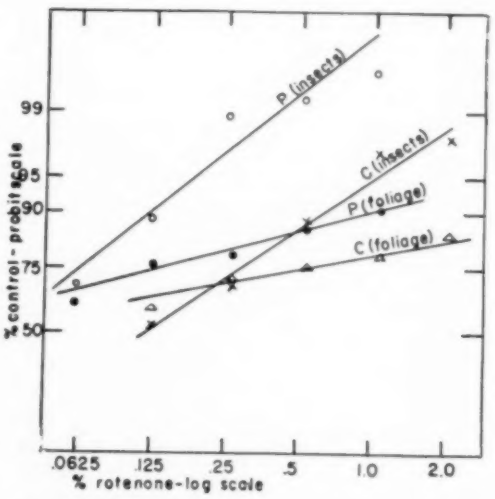

Fig. 5.—Dosage-response curves for derris with pyrophyllite (P) and clay (C) in controlling the Mexican bean beetle. Upper curves for insect control; lower for percentage of foliage not damaged.

[1] Results taken by Dr. J. G. Horsfall and Mr. A. I. McDonnell.

per cent with clay equalled 0.25 per cent with pyrophyllite (at the 80 per cent level).

Examination of the plots on September 1 indicated that 0.125 per cent or more rotenone with pyrophyllite and 0.5 per cent or more rotenone with clay had provided excellent commercial control.

Cabbage worms.—Late cabbage planted July 1 was dusted August 8, 18 and 31, using 24 pounds per acre. A rotary hand duster was used in all cases. There was a light infestation of the imported cabbage worm and diamond-back larvae, and moderate to severe infestation of the looper. Plots consisted of 11 plants in a row, and were randomized in blocks.

Table 6.—Control of cabbage worms using ground derris and two diluents.

Diluent	Rotenone	Not Damaged	Damaged Heads Marketable	Not Marketable
Pyrophyllite	0.25%	10.8%	48.7%	40.5%
	0.5	17.9	61.5	20.5
	1.0	30.8	66.7	2.5
Clay	0.25	4.9	22.0	73.1
	0.5	7.0	48.8	44.2
	1.0	15.8	47.4	36.8
None	None	0.0	17.9	80.1

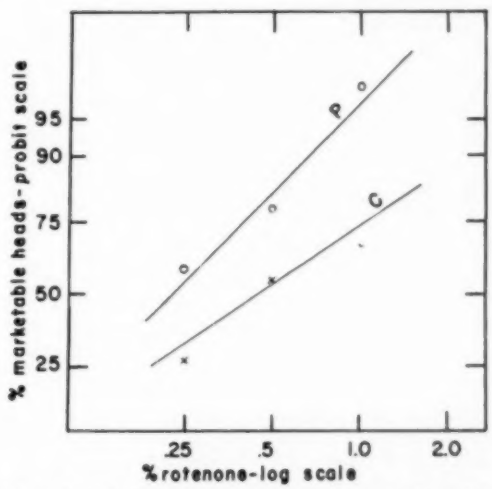

FIG. 6.—Dosage-response curves for derris with pyrophyllite (P) and clay (C) in controlling cabbage worms. Results in percentage of marketable heads

Results were taken in terms of degree of damage on August 25 and September 2. In addition the heads were harvested September 3 and 14 and graded according to the system of Reid *et al.* (1942). These results are presented in table 6 and figure 6. Since the head could be examined carefully after cutting, only the figures obtained during harvest are presented. Here again the pyrophyllite produced by far more marketable heads than clay. At the 70 per cent level, 0.35 per cent with pyrophyllite equalled 1 per cent with clay.

Table 7.—Dosage for equal control, field tests.

Insect	Level of Control (Per Cent)	Type of Control	Concentration Required Pyrophyllite (Per Cent)	Concentration Required Clay (Per Cent)
Potato flea beetle	80	Leaf damage	0.35	.9
	90	Leaf damage	0.825	2.4
Mexican bean beetle	80	Larvae	0.08	.32
	95	Larvae	0.2	1.00
	70	Leaf damage	0.1	.25
	80	Leaf damage	0.25	1.00
Cabbage worms	70	Marketable heads	0.35	1.00

DISCUSSION AND SUMMARY.—The review of the literature showed that both quantitative and qualitative differences had been observed between different diluents used with pure ground derris root. In this study dosage-response curves have been used to calculate the differences between the diluents. In the laboratory, pyrophyllite, flaky talc, fibrous talc and clay diluents were effective in the same order as found by Wilson and his coworkers (1942 a & b). Further, pyrophyllite actually increased the expected effectiveness of pure ground derris root when used in amounts of three parts or more to one part of root.

The character of the dosage-response curves obtained in the laboratory was such that no dosage for equal control could be obtained without extrapolation. In all cases, mortality following use of 0.25 per cent rotenone with pyrophyllite was higher than from 2 per cent rotenone with fibrous talc or clay. In other words, 1 gram of rotenone with pyrophyllite would produce more than 8 times the effect than if used with fibrous talc or clay. In the case of flaky talc and slate dust, 1 per cent rotenone was required to equal 0.25 per cent rotenone with pyrophyllite.

In the one cage test, variable results make comparisons difficult, but the dosage for equal control of striped cucumber beetles was approximately 4 to 1 in favor of pyrophyllite.

Dosage for equal control in the field tests is given in table 7. These figures indicate that 1 part of derris suitably diluted with pyrophyllite is as effective as from 2.5 to 5 parts of derris diluted with clay. Furthermore, these relationships hold at relatively high levels of control. If the control obtained by 1 per cent rotenone with clay is accepted as the desirable standard, not more than 0.4 per cent rotenone with pyrophyllite produced the same degree of control. Not more than 0.3 per cent rotenone with pyrophyllite would be required to equal the control following use of 0.75 per cent rotenone with clay.—12-2-42.

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PEACH QUARANTINES

Following the Federal-State inspection for the phony peach and peach mosaic diseases in 1942, the Bureau of Entomology and Plant Quarantine recommended in February 1943 that the restrictions of the phony peach disease standard State quarantines be lifted as to the entire States of Kentucky and North Carolina and a considerable number of counties in 5 other States; and that the peach mosaic quarantines be lifted as to the restrictions pertaining to 1 county in Utah, 2 each in California and Colorado, and 4 in Texas. All the above areas have been found free from either of these diseases for a period of at least 3 years. Four newly infected counties in Texas were recommended for addition to the regulated areas. The States which have thus far taken action to bring their quarantines into line with the standard areas are Arizona, California, Georgia, and Texas.

The State of Oregon on March 19, 1943, revoked its quarantine pertaining to the peach mosaic disease, inasmuch as it is believed that the uniform quarantines of the infected States adequately prevent the shipment of diseased stock from infected areas, the announcement states.

The Montana legislature has amended its law pertaining to the licensing of nurseries by lifting the bond requirement, effective July 1, 1943. Nursery fees are still required, ranging from $5 to $15 annually.

Effects of Oxygen and Sunlight on Decomposition of Rotenone in Spray Mixtures[1]

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The rotenone molecule contains double bonds, ether linkages, aromatic 5- and 6-membered ring systems, heterocyclic rings, and an aliphatic side chain. Such a molecule has several points of high electron density and would accordingly be expected to become readily highly activated by energy absorption. Furthermore, the characteristic ultraviolet absorption of rotenone exhibits a maximum at 295 mμ (Ke *et al.* 1940). Since analysis of the absorption spectrum of a precursor to vitamin D_2, ergosterol, shows an absorption maximum at 280 mμ (Fieser 1937), this fact would indicate that absorption in this region of the spectrum is associated both with the ability of the molecule to become activated on irradiation and with the presence of conjugated double bonds in the molecule (Windaus & Langer 1933). Moreover, the rotenone molecule possesses a true complex conjugated system. From these theoretical considerations alone, then, rotenone would be expected to be sensitive to the action of sunlight. It is the purpose of the present paper to report on the extent and nature of this photosensitivity and on the extent and nature of the oxidative decomposition of rotenone in certain spray mixtures.

LITERATURE.—As early as 1931, Jones (1931) reported that the autodecomposition of rotenone is accelerated by access to the air, but that it is not affected by differences in the amount of impingent light or by the presence of water. As might be expected from the fact that rotenone is extremely unstable in a basic solution, yielding dehydrorotenone, dl-isorotenone, and mutarotenone (Cahn *et al.* 1938a, b, c) Jones found, also, that pyridine solutions of rotenone decompose more rapidly than do solutions of rotenone in other organic solvents, whereas a benzene solution of the compound exhibits no appreciable decomposition. Dehydrorotenone and rotenononone were reported (Jones 1931) to be the products of this air oxidation; their crystals are deposited in a few days from a pyridine solution of rotenone.

In another paper, Jones & Haller (1931) reported that the rate of decomposition of rotenone in various organic solvents depends upon the solvent, the temperature of the solution, the access of air, and "other factors." The decomposition itself was found to be an air oxidation of rotenone, the initial products of the reaction being the yellow crystalline compounds, dehydrorotenone and rotenononone. Dry crystalline rotenone undergoes no such changes upon long standing, according to these authors.

In 1933, however, Jones *et al.* (1933) applied rotenone, dihydrorotenone, rotenone-hydrochloride, a rotenone-bentonite mixture, a rotenone-lampblack mixture, ground derris root, and powdered derris extractive, in paste form, to glass plates. Groups of these plates were exposed to direct sunlight for various lengths of time, or to an electric arc light for an equivalent number of hours. The controls were stored in the dark at room temperature. After exposure, the deposits were removed from the plates and tested for toxicity against mosquito larvae and goldfish. All but the dihydrorotenone and the rotenone-lampblack mixture lost more than half their toxicities during a 10-day exposure to sunlight, while the arc light practically destroyed their toxicities. The dihydrorotenone was more resistant and required 20 days in the sunlight for a similar loss of toxicity, but under the arc light it lost toxicity to approximately the same extent as rotenone. Lampblack seemed to protect the rotenone from the detoxifying action of both sunlight and arc light. Finally, Jones *et al.* (1933) reported that the photochemical decomposition of dry rotenone does not take place in the absence of oxygen.

The greater resistance of dihydrorotenone would, of course, be predicted from theoretical and structural considerations, for the ethylenic double bond has been

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[2] Laboratory Assistant in the Experiment Station, employed through grant furnished by the Irvington Varnish and Insulator Company.

[3] The author gratefully acknowledges the assistance rendered by Dr. Walter Ebeling, of the University of California Citrus Experiment Station, in suggesting and discussing certain phases of the work. Mr. J. J. Ortega, also of this Station, very kindly aided in the running of the analyses.

eliminated as one point of electron "hunger" (Ingold 1934).

For the analysis of rotenone solutions containing no other reducing substances, Whittaker & Glickman (1934) took advantage of this ease of oxidation of rotenone by adapting the method of Guadinger and Corl for the analytical determination of pyrethrins.

In 1934, Wheeler (1934) corroborated, in part, the work thus far reported by comparing the photodecomposition of rotenone with that of the pyrethrins. He found that the active constituents of derris root lose their toxicity on exposure to light, but at a much slower rate than the pyrethrins, and that the reaction involved is apparently one of photochemical oxidation, a yellow inert substance forming from the rotenone. On exposing to sunlight thin layers of a dust containing crushed derris root, barium fluosilicate, and sulfur, he found that in 25 hours the dust lost its characteristic derris odor, and that the concentration of rotenone decreased 40 per cent.

In a very extended investigation, Danckwortt *et al.* (1935a, b) also confirmed the fact that the rotenone content of derris preparations diminishes in a definite time, and that this decline is established without doubt in an alkaline solution of rotenone. These workers conducted experiments over a period of six months, and determined the rotenone quantitatively by the polarimetric method, as well as by "evaporation to a residue." The derris extracts used were those of commerce, prepared for the major part with carbon tetrachloride or chloroform as the extracting medium. Their quantitative data showed that there was a definite loss of rotenone content in nonalkaline solutions over a period of four months, the average loss being about 15 per cent. Whether or not these solutions were stored in the dark is not reported.

According to van der Laan (1935), however, dry rotenone crystals exposed to direct sunlight for 42 days did not retain any of their activity. He found, also, that derris powder is not so sensitive to illumination as rotenone, and that, if dry and protected from the sun, it may be kept for years. In the sun, though, the dry powder lost about 50 per cent of its activity in 3 days. In a soap solution, this powder lost much of its activity in 2 days.

Subramaniam (1936–37) found that aqueous suspensions of ground root of *Derris elliptica* deteriorated rapidly, but that similar alcoholic extracts were stable.

In 1938, Cahn *et al.* (1938c) found that rotenone is racemized by activated alumina, sodium acetate, or other mild alkaline conditions.

From a study of derris and cube roots, Goodhue & Haller (1939) concluded that the suspensions of the active (insecticidal) material, obtained by extracting the ground roots with water, were very stable if preserved against fermentation. The "active material" reported by these workers was probably not rotenone alone, but also the saponins known to be present in plants of the family Leguminosae; for other investigators (Gunther & Turrell 1943) have shown that such an aqueous extract can be filtered through a Seitz pad (No. 6), which will remove quantitatively all the suspended rotenone-containing resins, yet leave all the fish-killing saponins in true solution in the clear filtrate. Indeed, it is well known that saponins in general are excellent toxicants, and that rotenone is toxic to a relatively small number of organisms. Furthermore, Goodhue and Haller ran no bio-assays on their preparations, but relied upon the so-called Goodhue value (Jones *et al.* 1935; Goodhue 1936; Cahn *et al.* 1938c), which gives the approximate rotenone-deguelin content. In fact, Jones *et al.* (1935) state definitely that "it is impossible . . . to recommend unreservedly any one of these chemical determinations as a measure of the insecticidal effectiveness of rotenone-bearing plants. Further work is needed on this subject, particularly along the line of a more thorough study of the individual constituents present in such plant materials." Finally, the data of Goodhue & Haller (1939) show a decrease in "red color" for the water extract, after settling only 2 days, of an average of six units, or an unreported "loss in toxicity" of over 20 per cent.

Allen & Brooks (1940) found that rotenone-bearing dusts prepared from highly alkaline diluents and kept in damp storage in the absence of light for 7 days, exhibited no change in pH but showed considerable loss in toxicity when tested in kerosene extracts against houseflies. On the other hand, acidic dust samples that were similarly prepared and stored retained their

toxicity to the housefly, and dry or unmoistened alkaline and acidic samples also remained unchanged with respect to toxicity.

Jones & Haller (1931) reported that the rate of decomposition of rotenone in solution depends in part upon the temperature, but presented no supporting evidence. Feytaud & de Lapparent (1940) mixed a derris-root powder containing 6 per cent rotenone with talc to give an 85 per cent talc dust. This dust and the pure root powder were both tested insecticidally after being stored at a number of temperatures below 28° C. Both dusts behaved similarly under similar conditions, and Feytaud and de Lapparent concluded that the efficacy of rotenone-containing powders was not impaired by lowering of the temperature.

According to Ts'ai & Ke (1941), a study of the absorption spectra of solutions of rotenone in ethyl alcohol, saturated with carbon dioxide and with oxygen, exposed and unexposed to sunlight, showed that oxygen does not decompose rotenone in the dark. In light, however, these workers found a marked decomposition of the rotenone, an effect which did not seem to be due, appreciably, to the presence of oxygen.

The findings of Jones *et al.* (1931, 1933) indicated that light alone does not effect a photodecomposition of rotenone, but the more recent absorption-spectrum work (Ts'ai & Ke 1941) showed that oxygen is not necessary for this type of decomposition. Therefore, until further work is reported, the status of the problem of the photodecomposition of rotenone is such that it is deemed advisable to protect rotenone preparations against both the action of light and the effects of atmospheric oxygen, although the evidence accumulated seems to indicate that the oxygen effect is the less important of the two. In fact, a number of patents have been issued on ways of protecting rotenone (1) against the action of light, by such stabilizers as a chlorophyll green film[1] and a "red-sludge" by-product from the preparation of alumina;[2] (2) against the action of light and of oxygen, by salicylic acid, dichloroaniline, an aminophenol, or an anthranilic acid;[3] and (3) against the action of oxygen, by 1.5 per cent, or less, of lignicol, guaiacol, cresol, thymol, eugenol, resorcinol, pyrogallol, hydroquinone, α- or β-naphthol, naphthylamine, diphenylamine, or benzidine.[4]

The adverse effect of light on rotenone-containing insecticidal sprays is so possible that the Oregon Agricultural Experiment Station has advised (Robinson 1941) that rotenone must function as a spray within a few hours after application or its toxicity will be lost.

To recapitulate, then, the consensus of opinion seems to be that rotenone is very readily decomposed by the action of sunlight, both in the presence of and in the absence of oxygen, but that the presence of oxygen may produce a secondary effect. In addition, a decomposition of rotenone, due to the action of atmospheric oxygen alone, is certainly not improbable, particularly when the rotenone is in a basic medium.

NATURE OF THE PROBLEM.—In view of the probable importance of oxidative effects and of photo-effects in determining the ultimate efficacy of an insecticidal spray containing rotenone and/or its congeners, it was thought worth while to investigate these two phenomena quantitatively, with particular reference to practicability. In the present paper the results of two types of experiments, with specific spray materials, are reported. The first type of experiment deals with what appears to be an atmosphere-induced oxidation-reduction phenomenon; the second type deals with photodecomposition phenomena.

At the time of the work herein reported, *Cardolite 627*[5] was much in favor as a mutual solvent for sprays containing whole derris resin, or pure rotenone, and kerosene, or other oils (Ebeling 1940, 1941). This material was consequently among those tested.

OXIDATIVE DECOMPOSITION OF ROTENONE.—A standard "toxic [stock] solution" (Ebeling 1940, 1941)[6] was prepared by heating 4.0 pounds of *Cardolite 627*

[1] United States Patent No. 2,090,109 (M. R. Coe, Aug. 17, 1937).
[2] French Patent No. 848,974 (Motte & Pomot, Nov. 9, 1939).
[3] United States Patent No. 2,151,651 (L. J. Christmann & D. W. Jayne, Jr., Mar. 21, 1939).
[4] United States Patent No. 2,144,366 (D. B. Faloon, Jan. 17, 1939).
[5] A condensation-polymer of the phenolic constituents of cashew-nut-shell oil (cardanol) and formaldehyde, prepared and marketed by the Irvington Varnish and Insulator Company, Irvington, New Jersey.
[6] The use of the word "solution" to describe this mixture may be erroneous, for it now appears that it is really micellular in nature and should be classified among the colloidal systems.

with 2.0 pounds of commercial kerosene[1] to a temperature of 125° C. Then 0.82 pounds of powdered whole derris resin (30 per cent rotenone) was added, with rapid stirring, over a period of 30 seconds; stirring was continued for an additional 30 seconds. Immediately, 12.5 pounds of kerosene was added. After cooling to room temperature, two samples were drawn into browngless bottles. To one of the samples was added sufficient photographic-quality hydroquinone to make the mixture 1.5 per cent hydroquinone by weight. Since hydroquinone is not appreciably soluble in kerosene, an excess of the undissolved antioxidant was present in this sample throughout the duration of the experiment.

Table 1.—Periodic analyses showing oxidative decomposition of rotenone plus deguelin in two "stock solutions,"[1] one of which contained an anti-oxidant.

Date of Analysis	Rotenone-Deguelin Content[2] (Grams/Ml.) × 10^4	
	"Stock Solution"	"Stock Solution" Plus Anti-Oxidant
1941		
Dec. 17	8.2	8.2
1942		
Jan. 17	6.2	8.2
Feb. 17	4.6	7.8
Mar. 18	3.0	7.0
May 16	1.0	6.3
July 1	0.3	6.0
Aug. 3	0.2	5.8

[1] For explanation of "stock solution," see text page 275–6.
[2] In the analytical method, 2.0 ml. of the "stock solution" was diluted to 50.0 ml. with kerosene. Accordingly, the absolute rotenone-deguelin content in each instance may be obtained by multiplying the appropriate datum by 25.

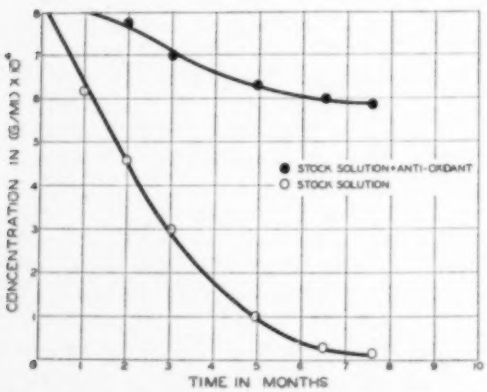

FIG. 1.—The effect of an anti-oxidant on oxygen-induced decomposition of rotenone plus deguelin in certain spray solutions.

After thorough shaking, 2-ml. aliquots were withdrawn from both samples and were immediately analyzed for their rotenone-deguelin content by means of a modification (Gunther 1942)[2] of the Gross & Smith (1934; Goodhue 1936) colorimetric method, after dilution to 50.0 ml. with kerosene. The samples were then stored in the dark at a temperature of 23° ± 4° C. Approximately once a month for eight months, aliquots were withdrawn and analyzed as before. To eliminate the possibility of the development of a saturation gradient, the sample containing the hydroquinone was well shaken at least once a week.

For the periodic rotenone-deguelin analyses, fresh colorimetric standards were made in exactly the same manner each time, from the same samples of pure rotenone, *Cardolite 627*, and kerosene, and with exactly the same weights of the respective constituents. The accuracy of the analytical method was checked thoroughly many times in this laboratory in routine analyses of both known and unknown *Cardolite*-containing spray mixtures. For example, some triplicate analyses of the solutions used in the present investigation varied among themselves by less than 5 per cent. The *Cardolite*, in the final concentration of the analytical procedure, did not interfere with the development of the requisite color or with its grading.

The analytical data for this oxidative-decomposition study are presented in table 1.

Rotenone-deguelin concentrations in "stock solutions" with and without an anti-oxidant, have been plotted against time intervals in figure 1. These two curves have several very interesting interpretations. The "stock-solution" curve appears to become eventually truly asymptotic: the familiar $\frac{1}{}$ mass-law relation is observed, for the concentration decreases with time and approaches zero concentration very slowly. This would indicate a condition approaching equilibrium. The curve for the treated "stock solution"

[1] Distillation range, 388–480° F.; unsulfonatable residue, 94–96 per cent.

[2] A further modification of the Gross and Smith colorimetric method for determination of rotenone has been devised by the author and is being prepared for publication.

("stock solution" plus anti-oxidant), on the other hand, is erratic in its behavior, and by itself means only that a condition of equilibrium has been attained slowly after an induction period. An induction period in the presence of an anti-oxidant is a common phenomenon, and this erratic behavior is to be expected. The two curves together may be interpreted to mean that the rotenone was decomposed by an oxidation mechanism, for the addition of an anti-oxidant retarded this decomposition tremendously. In fact, in the presence of the anti-oxidant, decomposition at the end of seven months was only one-thirtieth as much as that in the absence of the anti-oxidant.

In figure 2 the logarithms of the concentrations have been plotted against time intervals, for both samples. The straight lines produced indicate that the oxidation reaction in both cases is first-order and follows the equation.

$$-\log C = \left(\frac{k}{2.303}\right) t + \text{constant},$$

where k is the velocity coefficient, t is the time, and C is the concentration of rotenone plus deguelin. It has been assumed that "rotenone plus deguelin" acts as one component.

By reference to figure 1 it will be seen that it took twice as long for three fourths of the untreated "stock solution" to decompose as for half of it to decompose. This proves it to be a reaction of the first order. The test plots for second- and third-order reactions yielded unmistakable parabolas. These theoretical considerations have not been carried further because the data are not sufficiently extensive and because the systems involved are probably not true solutions (see footnote 1, p. 276). Since the foregoing facts seem to be incompatible with an oxidation theory, they are presented here merely as a suggestion for further work. It must be realized, however that they do not in any sense exclude the possibility of an oxidation mechanism for the proved decomposition of rotenone; the possibility that the reaction may be pseudo-unimolecular must not be overlooked.

PHOTODECOMPOSITION OF ROTENONE.—For the second phase of the present investigation, seven rotenone-containing hydrocarbon solutions (or mixtures) were used. These were as follows: (1) a saturated solution of pure rotenone in kerosene (note 2, p. 276); (2) a saturated solution of pure rotenone in a light-medium oil;[1] (3) a saturated solution of whole derris resin (30 per cent rotenone) in a light-medium oil; (4) a saturated extract of powdered derris root (6 per cent rotenone) in a light-medium oil; (5) a standard "stock solution" made according to the formula previously described (p. 275), but with a light-medium oil instead of kerosene; (6) the standard kerosene "stock solution," containing pure rotenone and diluted 1 to 70 with kerosene; and (7) an extract of 1.18 grams of powdered derris root (6 per cent rotenone) in 236.0 ml. of kerosene, filtered by means of suction after being agitated for 30 minutes at room temperature. Equilibrium conditions were insured by mechanically stirring each mixture for 20 minutes at room temperature and then storing each in the dark for 24 hours. All samples were filtered by means of suction, just prior to use in the tests.

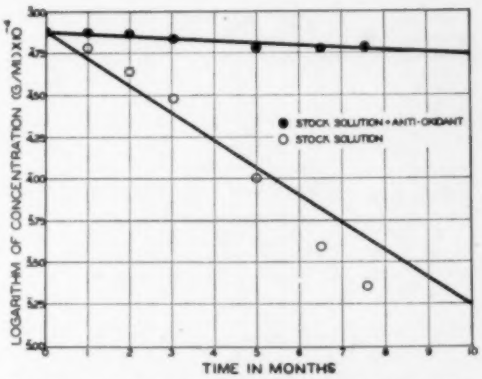

FIG. 2.—Determination of the order of the reaction between rotenone plus deguelin and atmospheric oxygen in a certain spray solution with and without an anti-oxidant.

For the photo-test, 20-ml. aliquots of each sample were pipetted into shallow, clear-glass cyrstallization dishes approximately 4 inches in diameter. A 1-ml. aliquot was withdrawn from each of these samples and analyzed immediately for its rotenone-deguelin content, by the method previously mentioned (p. 287). All the sample dishes were then placed in the

[1] Distillation at 636° F., 56 per cent; viscosity, 70 seconds Saybolt at 100° F.; unsulfonatable residue, 90 per cent. Commonly referred to as No. 3 oil.

direct afternoon sunlight on a flat, tan surface. The reflected intensity of the sunlight was 150 candles per square foot, as measured by means of a standard Weston light meter held 1 foot from the black rubber surface of a laboratory apron; this value did not vary more than 1 or 2 units during the experiment. As recorded by a laboratory thermometer, the temperature of the surface upon which the samples were placed was 48° C.

At regular intervals the samples were carried into the laboratory and allowed to cool to room temperature; after aliquots had been removed for analysis, the samples were returned to the sunlight. It was noticed that solutions 1, 3, 4, and 7 (Table 2) began to cloud after an exposure of approximately 30 minutes, and at 100 minutes' exposure had deposited flaky particles of a yellow amorphous substance (probably dehydrorotenone, rotenonone, etc.). Samples 2, 5, and 6, on the other hand, remained perfectly clear throughout the course of the experiment. No explanation for this behavior is offered at this time.

The analytical data for this photodecomposition study are presented in table 2. All runs were duplicated, and the values reported are the averages of two analyses.

Rotenone-deguelin concentrations have been plotted against time intervals in figure 3. All the preparations exhibited photodecomposition; but, in general, those containing kerosene showed a much greater proportional decrease in rotenone-deguelin concentration than those containing the light-medium oil. The derris resin-*Cardolite*-oil mixture (No. 5) exhibited the least decomposition under these drastic conditions, and the rotenone-*Cardolite*-kerosene mixture (No. 6) exhibited the least decomposition of the three samples containing kerosene. These facts indicate that the presence of *Cardolite* in some manner inhibits the photodecomposition, although, oddly enough, an aqueous solution of *Cardolite 627* (100 ml. of distilled water dissolves 0.006 grams of the polymer at room temperature) possesses a pH of 8.35.[1]

In figure 4 the logarithms of the rotenone-deguelin concentrations in samples 1 and 2 have been plotted against time intervals. The other samples were not included because it was felt that only two-component systems could be considered significant here. Although both sets of data yield straight lines in this figure and thus indicate the decomposition to be first-order, it should be kept in mind that

Table 2.—Periodic analyses showing photodecomposition of rotenone plus deguelin in certain hydrocarbon spray solutions exposed to direct sunlight for various periods of time.

Sample No.	Hydrocarbon Spray Solution[1]	Rotenone-Deguelin Content (Grams/Ml.)×10⁴ After Indicated Number of Minutes					Per Cent Rotenone-Deguelin Decomposition in 100 Minutes
		0	20	23	60	100	
1	Pure rotenone plus kerosene	2.8	—	0.8	0.4	0.1	96
2	Pure rotenone plus No. 3 oil	5.7	—	5.0	3.5	1.9	67
3	Whole derris resin (30 per cent rotenone) plus No. 3 oil	8.0	—	6.9	5.7	4.5	44
4	Powdered derris root (6 per cent rotenone) plus No. 3 oil	12.0	—	9.5	8.7	8.0	33
5	Whole derris resin—No. 3 oil "stock solution"	3.0	—	2.9	2.7	2.4	20
6	Pure rotenone-kerosene "stock solution"	2.8	2.8	—	2.4	1.6	43
7	Powdered derris root (6 per cent rotenone) plus kerosene	4.5	3.9	—	2.1	0.8	82

[1] Kerosene: distillation range, 388–480° F.; unsulfonatable residue, 94–96 per cent.
No. 3 oil: distillation at 636° F., 56 per cent; viscosity, 70 seconds Saybolt at 100° F.; unsulfonatable residue, 90 per cent.
*"Stock solution": explained on text page 276.

[1] Personal communication from the Irvington Varnish and Insulator Company.

photodecomposition or photosensitization reactions are usually of zero-order. In a zero-order reaction, the rate is unaffected by the concentration because it is determined by some other limiting factor, such as the absorption of light in a photochemical reaction. Nevertheless, it is conceivable kinetically that a photostationary state might exist in the systems under consideration. The decomposition reaction could, accordingly, be zero-order, and the reverse reaction could be first-order. If this were the case, the law of mass action would not apply directly to the system in that it would not lead to an equilibrium constant (Glasstone 1940).

DISCUSSION.—The foregoing discussions of experimental results have been confined principally to theoretical considerations; the present discussion concerns the practical aspects of the findings.

As shown in figure 1, a typical spray solution containing whole derris resin decomposes rapidly over a period of several months, but this decomposition of rotenone plus deguelin is inhibited by the addition of a small percentage of the antioxidant hydroquinone. The observed loss of toxic constituents was probably due to the oxidative reaction of the air in contact with, and in solution in, the spray concentrate. No attempt was made to isolate or identify the reaction products.

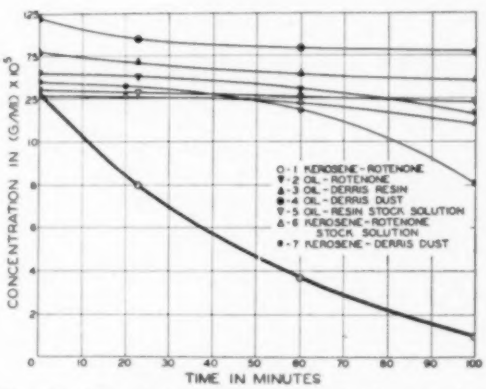

FIG. 3.—The photodecomposition of rotenone plus deguelin in certain hydrocarbon spray solutions.

In figure 3, it is evident that direct sunlight produced a very striking photodecomposition of rotenone, both in kerosene and in a light-medium spray oil. The use of whole derris resins, derris dust, or of *Cardolite 627* in the preparation of toxic solutions markedly decreased the rate of this decomposition, except when kerosene was employed as the solvent. When both kerosene and *Cardolite 627* were used together, however, the rate of the photodecomposition was so retarded as to be comparable with the best of the other results obtained.

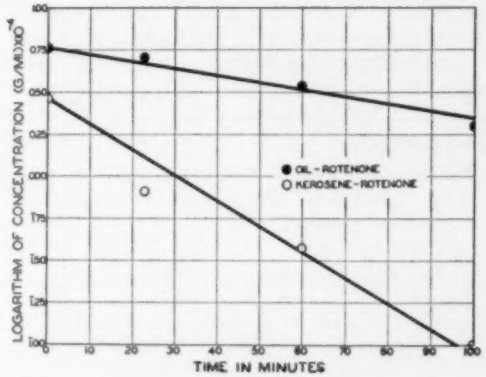

FIG. 4.—Determination of the order of the photodecomposition of rotenone plus deguelin in certain hydrocarbon spray solutions.

CONCLUSIONS.—Regardless of how soon a rotenone-containing spray is applied in the field after compounding, the deposit on the foliage will be microscopically thin. Such a deposit will be subjected to the most severe of adverse conditions, namely, those of maximum surface exposure to the air, of most intense direct sunlight, and of daily, recurrent temperature extremes.[1] In such a critical environment, a toxicant of proved instability—rotenone, for example—would hardly be expected to retain those structural characteristics necessary to toxicity. The fact that rotenone so quickly decomposes when subjected to isolated adverse factors, would imply that the combined effects of several such factors should at least be additive.

For maximum effectiveness, then, any spray preparation containing rotenone and/or its congeners should be protected, as far as possible, against the action of sunlight, the oxygen of the air, and high temperatures. Even so, the toxic action of these substances, *by themselves*, will be short-lived, as has been proved by large-scale field experiments.[2] In these experi-

[1] It has long been known as an empirical fact that many reactions approximately double or treble their velocities for a 10° rise in temperature.

[2] Unpublished data on file at the University of California Citrus Experiment Station, Riverside, California.

ments a high initial kill of the California red scale, *Aonidiella aurantii* (Mask.), was obtained easily in a variety of ways, but no residual effects on the progeny of the scales escaping the initial treatment were discernible when derris preparations were relied upon as the sole toxicants.

SUMMARY.—Analytical evidence has been presented to prove both the oxygen-induced decomposition and the photo-decomposition of rotenone and derris-containing preparations incorporated into spray materials. The theoretical and the practical aspects of the conclusions derived from the data are discussed. Several suggestions as to possible theoretical avenues of approach to further quantitative theoretical and practical analyses of the problem are made. The advisability of protecting all spray materials incorporating rotenone and/or its congeners against the adverse effects of atmospheric oxidation, sunlight, and high temperatures, is emphasized; these toxicants, by themselves, are drastically short-lived under field conditions.—11-24-42.

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Pea Aphid Control in Eastern Virginia in 1942[1]

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Of the insecticides used for the control of the pea aphid, *Macrosiphum pisi* (Kltb.), vaporized nicotine has given the most consistent and most effective results in eastern Virginia (Walker & Anderson 1940). However, vaporizing machines are very limited in number and it will probably be impossible to secure additional ones until after the war. Further, they are not very well adapted for use by the farmer growing a small acreage of peas. Nicotine- and rotenone-bearing dusts have given good results in some instances and poor results in others. The experiments here reported were carried on with the hope of developing a more reliable dust that could be applied with the equipment now on hand or available to the local farmer, and one that could be used in place of, or which would greatly conserve, our limited supply of rotenone.

The tests were conducted on Alaska peas which were sown broadcast. All tests were replicated 4 times. The plats varied in size, depending upon the size of the field in which the tests were conducted. The degree of control was measured by sweeping with an insect net 24, 72 and 120 hours after treatment. Care was taken not to sweep a given area more than once.

FIRST TEST.—The first experiment was designed to compare different strengths of rotenone-pyrophyllite dusts, both alone and in combination with *Lethane 60*, an aliphatic thiocyanate (Walker & Anderson 1942). The second experiment was designed to compare different types of nicotine dust, alone and in combination with rotenone and with a rotenone and a rotenone-*Lethane* dust. These dusts were applied with an eight-nozzle horse-drawn traction duster. The nozzles were set 18 inches apart and were enclosed in a cloth canopy behind which was attached a 35-foot cloth trailer to confine the dust around the plants. All of the rotenone bearing dusts used in this and subsequent tests were made from the same lot of cube powder, and pyrophyllite (*Pyrax ABB*) was used as the diluent except where otherwise noted.

The dusts used, the amount of dust applied per acre and the results obtained in the first test are given in table 1. The dusts were applied between 6:30 and 8:10 P. M. Although it has been quite windy during the day, the wind had died down almost to a complete calm before and during the dusting. The temperature ranged from 80° to 77° F. The relative humidity was 60 per cent at the start and 70 per cent at the end of dusting, with a few drops of rain falling while part of the dusts was being applied. An attempt was made to set the duster to apply from 40 to 45 pounds of each dust per acre, but it was impossible to get the duster to perform accurately with any given dust as shown by the variation in the amount of dust actually applied. In fact, it is believed that the uneven distribution of dust by the duster used would obscure any small differences that might exist between two dusts of nearly equal effectiveness.

A study of table 1 shows that *Lethane 60* and cube combinations containing as low as 0.2 per cent rotenone and 3 per cent *Lethane* were as effective as similar cube dusts containing from 0.75 to 1.0 per cent rotenone. Cube dusts containing 0.4 and 0.2 per cent rotenone were not as effective as similar dusts to which 3 per cent by weight of *Lethane 60* had been added. A

[1] Eastern Branch Program; New York, November, 1942.

Table 1.—Comparison of cube dust with different rotenone contents when used alone and in combination with *Lethane 60* for the control of the pea aphid at Onley, Virginia in 1942.

Pyrophyllite was used as the diluent in all cases.

Content of Dusts Used		Pounds of Dust Used per Acre	Average Number of Aphids per Sweep of an Insect Net[1]		
Per Cent Rotenone	Per Cent *Lethane 60*		24 hour count	72 hour count	120 hour count
0.6	3.0	35	13.8	3.8	4.7
0.4	3.0	45	7.9	2.6	2.8
0.4	2.0	51	7.6	2.8	4.4
0.2	3.0	50	8.8	2.5	3.4
	3.0	39	11.3	6.3	10.3
1.0		49	14.1	4.3	4.1
0.75		44	12.3	4.8	4.1
0.75[2]		42	14.5	5.0	4.3
0.4		54	20.0	8.7	9.4
0.2		45	24.7	13.1	17.9
Untreated check			54.9	28.1	52.8
Difference required for significance			9.3	5.3	4.5

[1] Average is based on 100 sweeps of an insect net.
[2] Two per cent peanut oil and one per cent *Vatsol OS* were included in this dust.

dust containing 3 per cent *Lethane 60* alone was more effective than a cube dust containing 0.2 per cent rotenone. The cube dust containing 0.75 per cent rotenone was as effective as a similar dust containing 1.0 per cent rotenone. The addition of 2 per cent peanut oil and 1 per cent *Vatsol OS* did not improve the killing properties of a cube dust containing 0.75 per cent rotenone as measured by these tests. Also, the cube dusts containing 0.75 and 1.0 per cent rotenone were more effective than those containing 0.2 and 0.4 per cent rotenone.

Yield records taken on these plats at harvest time indicated that the aphids had not caused much damage, as the untreated check plats yielded nearly as much as did the treated plats. This was undoubtedly due to the fact that the infestation did not develop until after the pods were well set and beginning to fill.

In addition to this test, a small experiment was conducted to compare a cube dust containing 0.4 per cent rotenone with one containing 0.4 per cent rotenone plus 3 per cent *Lethane 60*. After 120 hours the peas treated with the rotenone dust had an average of 40 aphids per sweep of an insect net while those treated with the rotenone-*Lethane* dust had an average of only 21 aphids per sweep. There was a rather gusty wind which averaged from 8 to 10 miles per hour while these dusts were applied and this probably helps to account for the poor kills obtained with both dusts.

Second Test.—The second test was applied between 10:45 A. M. and 1:45 P. M. on the day following the first experiment. This test was designed to compare different forms of nicotine dust with nicotine-rotenone, with a rotenone and with a rotenone-*Lethane* dust. The temperature ranged from 75° F. at the start to 78° F. at the finish and the relative humidity ranged from 48 to 43 per cent. The wind was rather gusty and varied from 2 to 7 miles per hour as measured during single minute periods. The materials used and the results obtained are given in table 2.

In this test all of the treated plats showed significant decreases in aphid populations as compared with the untreated check plats. However, there was so much variation in the results obtained that there was little significant difference between treatments. There was a tendency for the nicotine dusts to give a quicker kill than did the rotenone, but the rotenone had more residual effect than did the nicotine.

Third Test.—A third experiment was conducted to check further on the relative merits of some of these dusts. The materials were applied with a large duster, equipped with a worm gear feed designed to give a uniform, accurate feed of dust. This duster was mounted on a truck with the dust boom enclosed in a gas tight compartment, behind which was drawn a 50-foot gas tight apron. The dusts were applied between 11:15 A. M. and 4:25 P. M. when the temperature varied from 63° F.

Table 2.—Comparison of various nicotine and nicotine-rotenone dusts with a rotenone and a rotenone-*Lethane* dust for the control of the pea aphid at Onley, Virginia in 1942.

Dusts Used	Pounds of Dust Used per Acre	Average Number of Aphids per Sweep of an Insect Net[1]		
		24 hour count	72 hour count	120 hour count
Black Leaf 10[2], 4.0% nicotine Pyrophyllite	41	16.2	13.8	42.5
Black Leaf 155[2], 4.0% nicotine Hydrated lime	56	47.5	31.0	75.5
Black Leaf 40[2], 4.0% nicotine Monohydrated copper sulphate 8.0% Hydrated lime	45	20.8	27.3	58.8
Black Leaf 10, 3.0% nicotine Pyrophyllite	43	35.5	31.7	45.3
Black Leaf 10, 3.0% nicotine Cube 0.5% rotenone Pyrophyllite	45	45.0	46.7	63.3
Black Leaf 10, 3.0% nicotine Cube 0.25% rotenone Pyrophyllite	47	26.3	25.5	42.2
Black Leaf 10, 2.0% nicotine Cube 0.5% rotenone Pyrophyllite	43	63.2	58.0	66.2
Cube, 1.0% rotenone Pyrophyllite	39	55.8	36.3	35.3
Cube, 0.6% rotenone *Lethane 60*, 3.0% Pyrophyllite	32	54.5	41.3	54.0
Untreated check		364.8	166.2	223.0
Difference required for significance		19.9	20.0	38.5

[1] Average is based on 60 sweeps of an insect net.
[2] *Black Leaf 10* is made by impregnating finely ground tobacco stems with 10 per cent by weight of free nicotine. *Black Leaf 155* is a fixed nicotine on a bentonite carrier containing 14 per cent nicotine. *Black Leaf 40* is 40 per cent nicotine sulphate.

to 69° F. and the relative humidity ranged from 64 to 47 per cent. The wind ranged from about 8 miles per hour at the start to about 3 miles per hour at the finish. The nicotine dusts were applied first, followed by the nicotine-rotenone, rotenone, and rotenone-*Lethane* dusts, with the weather conditions probably favoring the dusts applied last.

The dusts used and the results obtained are given in table 3. In general the results showed that *Black Leaf 10*-cube dusts, containing from 2 to 3 per cent nicotine and from 0.25 to 0.50 per cent rotenone, were about equally effective. They were more effective than the 3 and 4 per cent nicotine dusts, except for a *Black Leaf 155* dust containing 4 per cent nicotine which gave better results than usual. In this test the addition of 2 per cent peanut oil and 1 per cent *Vatsol OS* to a cube dust containing 0.75 per cent rotenone failed to improve its effectiveness. When a dust containing 0.75 per cent rotenone was applied at 60 pounds per acre it was only slightly more effective than it was at 41 pounds per acre. A cube dust containing 0.4 per cent rotenone and 3 per cent *Lethane 60* was as effective as one containing 0.75 per cent rotenone with an indication that a dust containing 0.2 per cent rotenone and 3 per cent *Lethane 60* might not be quite as effective. However, this difference in effectiveness was not great enough to be statistically significant.

FOURTH TEST.—A fourth experiment was conducted to secure additional comparisons between *Black Leaf 155*, *Black Leaf 10*, *Black Leaf 10*-rotenone and rotenone dust. These dusts were applied with

Table 3.—Comparison of several nicotine, nicotine-rotenone, rotenone, and rotenone-*Lethane* dusts for the control of the pea aphid at Machipungo, Virginia in 1942.

Dusts Used	Pounds of Dust Used per Acre	Average Number of Aphids per Sweep of an Insect Net[1]		
		24 hour count	72 hour count	120 hour count
Black Leaf 10, 4.0% nicotine Pyrophyllite	57	13.1	15.5	61.4
Black Leaf 155, 4.0% nicotine Hydrated lime	52	24.4	12.1	32.9
Black Leaf 40, 4.0% nicotine Monohydrated copper sulphate 8% Hydrated lime	42	31.6	30.1	78.5
Black Leaf 10, 3.0% nicotine Pyrophyllite	43	18.7	32.1	67.0
Black Leaf 10, 3.0% nicotine Cube .25% rotenone Pyrophyllite	48	15.2	15.2	29.4
Black Leaf 10, 3.0% nicotine Cube .50% rotenone Pyrophyllite	48	23.2	17.4	26.0
Black Leaf 10, 2.0% nicotine Cube .50% rotenone Pyrophyllite	50	29.5	21.8	29.8
Cube, 0.75% rotenone Peanut oil 2.0% *Vatsol OS* 1.0% Pyrophyllite	52	28.4	20.9	17.7
Cube, 0.75% rotenone Pyrophyllite	60	22.5	11.5	8.5
Cube, 0.75% rotenone Pyrophyllite	41	23.3	14.5	14.8
Cube, 0.4% rotenone *Lethane 60*, 3.0% Pyrophyllite	36	17.5	20.1	13.5
Cube, 0.2.0% rotenone *Lethane, 60*, 3.0% Pyrophyllite	39	21.3	17.2	23.7
Untreated check		183.0	197.0	237.2
Difference required for significance		43.7	9.7	24.0

[1] Average is based on 100 sweeps of an insect net.

the duster used in the third test, between 2 and 4 P. M. on a calm day with a temperature of 82° F. Enough pyrophyllite in the rotenone-bearing dusts was replaced with dusting sulphur to be equivalent to 25 per cent of the total dust. The dusts used, the amount applied per acre and the results obtained are given in table 4.

In this test the *Black Leaf 10*, 4 per cent nicotine dust, and the cube dust containing 0.75 per cent rotenone were about equally effective while the *Black Leaf 155*, 4 per cent nicotine dust was decidedly less effective than any one of the others. However, there was an indication that the *Black Leaf 10*-rotenone dust with sulphur added might be better than the rotenone dust whereas in all of the other tests with a similar *Black Leaf 10*-rotenone dust but without sulphur the indication was in favor of the dust containing 0.75 per cent rotenone.

SUMMARY.—A 4 per cent nicotine dust made from *Black Leaf 40* was nearly as

effective as one made from *Black Leaf 10*, while a 4 per cent nicotine dust made from *Black Leaf 155* was better than either of these in one test and not as good in two others. This agrees with the authors' unpublished data on the control of the cabbage aphid, *Brevicoryne brassicae* (L.), and the spinach aphid, *Myzus persicae* (Sulz.), in which dusts made with *Black Leaf 155* gave good results in some tests and rather poor results in others. A 3 per cent nicotine dust made from *Black Leaf 10* gave nearly as good results as did one containing 4 per cent nicotine. *Black Leaf 10* dusts containing 2 or 3 per cent nicotine in combination with 0.25 or 0.50 per cent rotenone gave about the same initial kill but had more residual effect than did the 4 per cent nicotine dusts. Except for the nicotine-rotenone-sulphur dust used in the fourth test the nicotine-rotenone dust combinations did not give quite as good control as did cube-pyrophyllite dusts, containing 0.75 and 1.0 per cent rotenone. However, none of the differences between these dust combinations were statistically significant.

Table 4.—Comparison of a *Black Leaf 155* dust with a *Black Leaf 10*, a *Black Leaf 10*-Rotenone and a rotenone dust for the control of the pea aphid at Machipungo, Virginia in 1942.

Dusts Used	Pounds of Dust Used per Acre	Average Number of Aphids per Sweep of an Insect Net[1]	
		72 hour count	120 hour count
Cube, 0.75% rotenone Sulphur 25% Pyrophyllite	56	26.1	19.5
Black Leaf 10, 2% nicotine Cube, 0.5% rotenone Sulphur 25% Pyrophyllite	52	3.8	5.7
Black Leaf 155, 4% nicotine Hydrated lime	49	74.4	85.5
Black Leaf 10, 4% nicotine Hydrated lime	52	14.8	18.4
Untreated check		258.8	259.4
Difference required for significance		42.8	36.4

[1] Average is based on 100 sweeps of an insect net.

Cube-pyrophyllite dusts containing 0.75 or 1.0 per cent rotenone were significantly better than those containing 0.2 or 0.4 per cent rotenone. The addition of 2 per cent peanut oil and 1 per cent *Vatsol OS* did not improve the effectiveness of a cube dust containing 0.75 per cent rotenone. A cube dust containing 0.75 per cent rotenone was only slightly more effective when applied at the rate of 60 pounds per acre than when applied at the rate of 41 pounds per acre. Cube dusts containing 0.2 or 0.4 per cent rotenone plus 3 per cent by weight of an aliphatic thiocyanate (*Lethane 60*) were as effective in controlling the pea aphid as any of the other dusts tested, with an indication in one test that the dust containing 0.2 per cent rotenone might not be quite as effective as the dust containing 0.4 per cent rotenone. The cube dusts containing *Lethane 60* gave significantly better results than did similar dusts without the *Lethane 60*.—12-2-42.

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The Effect of the Hot Water Treatment for Cyclamen Mite upon Cyclamen Plants[1]

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During the late fall of 1938 requests were received from three Connecticut florists for information on the control of the cyclamen mite, *Tarsonemus pallidus* Banks, infesting cyclamen plants. In a review of the literature it was found that various methods had been recommended for the control of the mites upon different kinds of plants. Britton, *et al.* (1914) recommended *Black Leaf 40* plus soap, and firtree oil as sprays for snapdragon and chrysanthemum. Garman (1917) mentions bordeaux mixture, *Black Leaf 40* plus soap, or syringing with water for geraniums; Whitcomb (1927) reported successful control by naphthalene fumigation; Garman, H. (1884), and Munger (1933) reported on the use of hot water as a treatment for cyclamen plants. Munger stated that treatment with hot water at a temperature of 115° F. for a period of 5 minutes injured the cyclamen flower buds. Smith reported on the successful treatment of cyclamen plants with hot water at a temperature of 110° F. for 15 minutes, also on the use of vapor heat (Smith 1933) and later, on methyl bromide fumigations for controlling the cyclamen mite (Smith & Latta 1939).

As local experience as well as results obtained by various workers indicated that sprays were not entirely successful in controlling the mite on cyclamen plants, the growers were informed of the hot water treatment. A coöperative arrangement was made whereby the writer would treat a number of plants by this method in the separate establishments, assisted by the growers.

The cyclamen plant as commercially grown usually makes most of its growth in the months of August through December. These treatments were made in early December, 1938. All plants were wholly submerged in water having a temperature of 110° F. for a period of 15 minutes. The temperature was maintained by a thermostatically controlled electric heating unit and the water in the tank, which held about 19 gallons, was slowly agitated by a propeller electrically operated and controlled by a rheostat.

The first group consisted of approximately 70 plants in 6-inch pots in various stages of advanced buds and bloom. These were treated on December 6 and 7. The varieties were pure white, white with pink eye, light pink and magenta. In 12 days, a few leaves (one to three) had turned yellow on a number of the treated plants. The pure white, a robust variety, was more susceptible as a number of large buds showing color had wilted. On December 29, 22 days after treatment, numerous buds had wilted and collapsed on many of the plants, while others lost a large number of leaves. All the plants were injured, varying from slight to severe. The results could not be considered successful from a commercial standpoint.

A second group, consisting of 10 plants and including the varieties Pure White, Bonfire, America, Rose of Zehlendorf, Pearl of Zehlendorf, Dark Red and Light Salmon, in 6-inch pots, was treated in the same way in another establishment on December 9, 1938. These plants were in excellent condition and not as far advanced as the first group. Some of the plants were in full bud, showing a little color, with the longest bud stems about three inches long, while the remaining plants had fewer buds with shorter stems. When the plants were examined 20 days after the treatment a number of buds and a few leaves on various plants had wilted. As the length of time increased after treatment this condition grew worse. Five to 6 weeks after the treatment the majority of the buds had wilted while some bloomed prematurely at or below the height of the leaves. Numerous leaves had also wilted, causing a decided thinning of the foliage on a few of the plants.

The third group of plants treated on December 13, 14 and 15 included 112 heavily infested plants in 5- and 6-inch pots. Mites and eggs were present in large numbers on all parts of the plants. The leaves were severely deformed and prac-

[1]Eastern Branch Program, New York, November, 1942.

tically all the buds were killed. After the treatment, on December 29, a large number of leaf and flower buds were examined under a binocular microscope. No live mites were seen and most of the eggs were brown in color and had collapsed. A few eggs retained their original color but two weeks elapsed without any indication of hatching. Similar observations were made on large infested flowering plants which were treated from time to time in January and February, 1939. Tight flower buds an eighth-inch in length as well as larger buds were examined and in all cases 100 per cent mortality was obtained with the exception of one plant where one mite was found under one bud scale.

These results verified the findings of Smith (1933) that the hot water treatment at 110° F. for 15 minutes controlled the cyclamen mite. However, it was found that injury occured and the evidence was that the older plants were more severely injured by the treatment. Therefore, an arrangement was made with one of the growers to treat a number of younger plants when ready in the summer of 1939. A total of 357 plants of the varieties previously named, in 3- and 4-inch pots were treated on August 25 and 26, leaving 25 untreated additional plants as checks. These plants were examined from time to time throughout the rest of their development. No apparent injury was noted at any time, and about six weeks after the treatment the plants appeared to be more advanced than the untreated. However, this difference disappeared in less than a month and all the plants developed normally until they matured. These plants were sold wholesale at good prices to the Christmas trade.

The varying success with the hot water treatment indicated that an initial period occurs in the growth of the cyclamen plant beyond which the results of treatment would be commercially undesirable. A series of treatments at intervals was planned and made during the growing season of 1941. Two groups of plants were used, the first from an early seeding in 1940 and the second from seeds planted during August, 1940. The plants from the first and oldest group included the varieties Blood Red and Orange Beauty in 3-inch pots, and were received in February. The varieties in the second group—Pure White, Bonfire, Salmon Scarlet and Rose of Zehlendorf—were out of flats, ready for 2½- and 3-inch pots, and were received in May. All of these plants received the same cultural attention. The plants were shifted into larger pots when required, excepting some of the first group—the Blood Red and Orange Beauty—which were allowed to become nearly pot-bound in 4-inch pots to bring them into early bud and bloom. Likewise, a number of the second group of plants, including the four other named varieties, were brought in bud and bloom in 4-inch pots. The first group produced their first flowers in August while the second group did not produce flowers until late October or early November.

The first treatment of this series was made on March 21, using 15 plants each of the Blood Red and Orange Beauty well established in 3-inch pots. Approximately half the plants of each variety were exposed to the direct sunlight immediately after the treatment while the others were shaded with newspapers for 3 or 4 days. The shaded plants were not checked in growth and progressed rapidly, while the unshaded recovered more slowly. However, in 3 weeks the unshaded plants were equally progressive. The only other effect of the treatment observed was the minor loss of one or two of the first leaves, which was more noticeable on the unshaded plants.

The second treatment of the series, which included all six varieties, and totalled 173 plants, was made on August 5 and 6. All the plants were in either 3- or 4-inch pots, with the Blood Red and Orange Beauty more advanced in growth and a number having buds and first flowers. The other varieties were also in excellent growth, without buds and the foliage less mature. The treatment did not cause any perceptible check in growth but a number of buds and leaves wilted on the more advanced plants of the Blood Red and Orange Beauty varieties. This loss of buds and leaves was not very serious as the general condition of the plants was not particularly impaired.

A third treatment in this series was made on September 17. This group consisted of 45 plants in 4-inch pots and included all six varieties. The Blood Red and Orange Beauty plants had numerous buds and blooms, were nearly pot bound and close to maturity. The other varieties, while younger, were heavily rooted, grow-

ing strongly and without buds or blooms. All of the plants had been treated before, 10 of the Blood Red and Orange Beauty on March 26 and the others on August 5 and 6. The result of this treatment upon the more advanced plants of the Blood Red and Orange Beauty varieties was much more severe than found six weeks earlier. A great many of the buds, both large and small, wilted, while three plants not quite as advanced lost some buds. These three were able to recover during the next two months and developed into good plants by Christmas. The other four varieties, though younger and previously treated only six weeks before, continued to develop normally.

Another group in the series, the fourth, totaling 30 plants previously treated on August 5 and 6, were again treated on October 2. These plants were in very good condition, and 23 of them were in 4-inch pots, while the other seven were in 5-inch pots. As all these plants had been repotted when required, the Blood Red and Orange Beauty varieties, though well advanced into bud and blooms, were not as mature in growth as those of the same variety in 4-inch pots treated on September 17. The other varieties had not been repotted so their condition was similar to those treated in the preceding group, but 16 days older. After this treatment all the plants continued their rapid development excepting those of the Blood Red and Orange Beauty varieties. These varieties, in good growing condition before the treatment, lost numerous buds and leaves, resulting in lighter plants later in the season.

The fifth group in the series, totaling 44 plants, was treated on October 27. At this time the Blood Red and Orange Beauty plants were well developed and in bud and bloom, while the other four varieties were beginning to show their first flowers and were budding rapidly. After the treatment numerous leaves and some buds wilted on a number of the plants. This condition was more serious on the older and more mature plants of the Blood Red and Orange Beauty varieties. The injury to the other four varieties was similar and about the same as that obtained on the Blood Red and Orange Beauty varieties treated August 5 and 6 when their stage of growth was comparable.

A sixth and more mature group of 37 plants in the series was treated on November 5. This treatment caused more injury to the plants than that occurring in the preceding groups as more leaves and buds wilted. The severity of the injury apparently depended on the condition of the individual plant. Some of the Blood Red and Orange Beauty plants lost all of their flower buds.

The last and seventh group of plants, 20 in all, was treated on November 24. All of the plants were mature and were in bud and bloom, many of them fine specimens. After the treatment a number of the plants collapsed or lost all their buds and many leaves. Every plant was injured to such an extent that its value in commerce would have been greatly decreased.

SUMMARY AND CONCLUSIONS.—Treatment with hot water at 110° F. for 15 minutes of more than 100 cyclamen plants in 5- and 6-inch pots, in various stages of bud and bloom, severely injured the plants. The majority of the plants lost numerous buds and blooms two or more weeks after the treatment, which lessened their commercial value, while a few plants were a total loss. Other groups, totaling more than 125 plants, heavily infested with the cyclamen mite, were treated in a similar manner to observe the effect of the treatment upon the mites. Mortality of 100 per cent was obtained with one exception, when a single live mite was found under a bud scale.

These treatments indicated that the reaction of the plants varied greatly and that injury occurred and increased as the plants approached maturity. Because of the variations in plant response, a series of seven treatments was made in one season with six varieties of plants in different stages of growth. All the plants were successfully treated at intervals before flowering buds appeared. However, as soon as the plants became pot-bound and plant growth was checked or flower buds were produced, the treatment caused a noticeable number of buds and leaves to wilt. The greatest injury and actual loss of plants occurred in October, November or early December when the plants were in various stages of bud and bloom.

It may be concluded from the results obtained that the initial period at which injury due to the hot water treatment occurs comes at that stage of plant growth when the flower buds begin to appear. Further, if treatments are made after the

flower buds appear, the injury will increase progressively with older plants. In general, under commercial conditions, growing cyclamen plants should be treated not later than late August or early September when the early flower buds may be expected. Complete kill of the cyclamen mite at this time, together with care to prevent reinfestation, will probably permit the successful production of cyclamen plants.—12-2-42.

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Two Pests of Legumes: *Alydus eurinus* Say, and *A. pilosulus* Herrick-Schaeffer[1]

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The broad-headed bugs, *Alydus eurinus* and *A. pilosulus*, are fairly common in Virginia. The nymphs and adults of these insects attack nearly all legumes, both cultivated and wild, causing considerable damage to the seedpods. It seems probable also that seed-borne diseases may be transmitted by the insects. This paper gives data collected at Richmond during the years 1928 to 1933 and also some observations in 1942. Blatchley (1926) gives the distribution of *A. eurinus* and *A. pilosulus* as from Quebec and New England west to the Pacific Coast and south to Florida but states that the latter species seems to be more common south and east. Chittenden (1902) received information in 1901 from F. E. Brooks of French Creek, West Virginia, of injury to lima beans and late cowpeas by *A. pilosulus*. It was thought that they were responsible for the diseased condition of cowpeas. Blatchley (1926) quotes McAtee as having observed *A. eurinus* on carrion in Virginia but the writer has not found the insects associated with carrion. *A. pilosulus* was reported in 1931 very abundant in one bean field in Connecticut by Friend & Turner (1931), and during the same season Clarke (1931) observed both species feeding on beans in Georgia. Bissell (1938) reports both species abundant on cowpea pods at Experiment, Georgia in 1938.

Both species have been taken in Virginia from the tidewater section in the east to the mountainous region in the west. *Alydus pilosulus* has usually been collected in larger numbers than *A. eurinus*. The broad-headed bugs infest cultivated and wild legumes such as alfalfa, lespedeza, vetch, clover, bean, and pea. Among the wild food plants, the tick trefoil group (*Desmodium*), the bush clovers (*Lespedeza*), and the senna weeds (*Cassia*) are favored. Of field crops, lima beans, soybeans, and cowpeas are preferred as food plants. The broad-headed bugs, both in the nymphal and adult stages, feed on nectar from nectar glands on the petiole and leaf and on the stems of legumes until the seed pods develop. They readily attack the seed pods, showing a preference for those maturing and almost dry. The adults take wing quickly, making a noise somewhat similar to that made by flesh flies, although they are weak fliers. Nymphs and adults run rapidly and hide under debris. When disturbed they may soon come from their retreat and exhibit

[1] Eastern Branch Program, New York, November 1942.

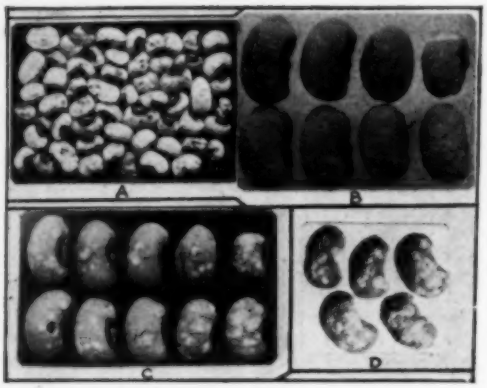

FIG. 1.—Cowpea seed injured by broad-headed bugs. A—general appearance of damaged cowpeas; B—Severely and lightly injured cowpeas with the skin left on; C and D—Same. With the skin removed showing white starchy areas where bugs fed on maturing seeds.

curiosity. The adults, especially the females, give off a disagreeable odor when disturbed on a hot day. The insects seem to prefer well-drained locations with sunny exposures. Open abandoned weed fields, lespedeza, clover and alfalfa sod land, uncultivated orchards, field borders, and places with a heavy growth of host plants and with debris on the ground are favorable. The adults migrate from such natural breeding grounds to nearby bean and pea fields particularly in late summer and fall.

ECONOMIC IMPORTANCE.—In these studies, injury by the broad-headed bugs has been most severe on lima beans and cowpeas. The chief injury to these crops is the result of the feeding of the insects on the maturing seed pods (Fig. 1, A, B and C). Studies were made to determine the effect of the feeding punctures on the germination of blackeyed cowpeas. Seed collected in Henrico County, Virginia in 1931 had the following germination test. When the seed had no feeding punctures 71 per cent germinated, seed with 2 or 3 punctures 35 per cent germinated, and when there were several feeding areas only 15 per cent germinated. Although 15 per cent of the last group did germinate, 68 per cent of the plants failed to develop. Many were crooked and had no leaves. In 1932, germination was somewhat higher, but the average results for the two years (Fig. 2)

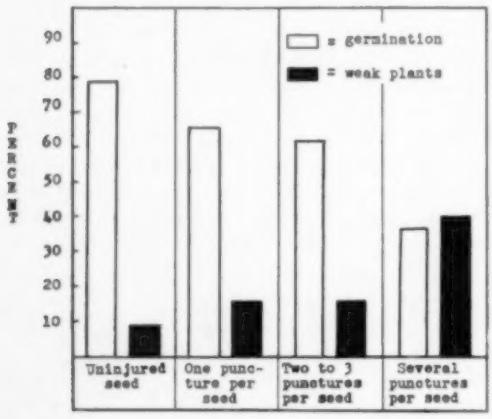

FIG. 2.—Germination and plant vigor data for cowpea seed injured by broad-headed bugs. Averages for 2 seasons, 1930 and 1931. The weak plants indicated in the third and fourth columns had cotyledons badly deformed and many did not develop any leaves.

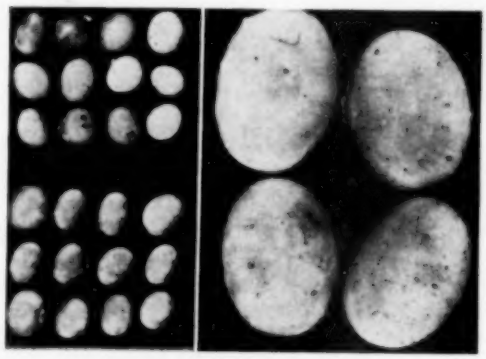

FIG. 3.—Soybean seed injured by adult broad-headed bugs, October–November 1942. Left, Above—Seed collected in the field with few punctures visible; Left, Below—Seed from cage plants which show many lesions and pustules where bugs fed; Right—Same as Left, below, much enlarged.

indicated that the feeding punctures reduce the germination of the seed and lower the vigor of the plants. In the fall of 1942 a soybean field at Blacksburg was carefully examined. Both species of bugs were presented but *Alydus pilosulus* was most numerous. The damage to the seed is indicated by Fig. 3.

The characteristic injury to seed may be described as follows: *Cowpeas.*—Seeds attacked while green and immature will be undersize and deformed. The feeding areas on more mature seed are starchy white and more or less depressed. These areas extend to the center of the seed. *Soybeans.*—The injurious effect of feeding is not so evident as on cowpeas. Beans attacked before maturity generally show elevated pustules with more or less white exudate at the feeding spot. Those attacked while

pods are drying may merely show a puncture through the skin. In either case there is often some discoloration around the feeding area.

DESCRIPTIONS. *Alydus eurinus.*—The eggs are round, slightly flattened, from 0.8 to 1 millimeter in length. They are bluish when first deposited, later changing to dark-brown. The surface is shiny, rough, distinctly sculptured. The eggs are deposited singly and lie on the ground without attachment. Nymphs of all stages are reddish in color following molting but change rapidly to dark-brown or black. They are somewhat ant-like in general appearance and may be mistaken for ants by the casual observer. They may be easily distinguished from ants, however, by the following characters: long pointed head, with prominent eyes and 4-jointed beak; broad union between thorax and abdomen; hump on dorsal part of abdomen containing scent glands; longer legs and more rapid movement over short distances; and the peculiar manner in which these insects sway the antennae and abdomen.

The first instar averages 2.25 to 2.75 millimeters. Color almost black; two basal segments of abdomen with greenish to reddish tinge; mesothorax velvety black dorsally, with a white point on central posterior border; terminal joint of antenna reddish-brown (Fig. 4, A).

The second instar averages 3 to 4.5 millimeters. Color generally very dark; mesothorax brownish, velvety on central dorsal area; posterior dorsal part of metathorax with two or three reddish tinged short stripes on each side—somewhat resembling the United States National Coat of Arms. (These stripes are present in third and fourth instar.) Abdominal segments smooth and shiny, except in the area of

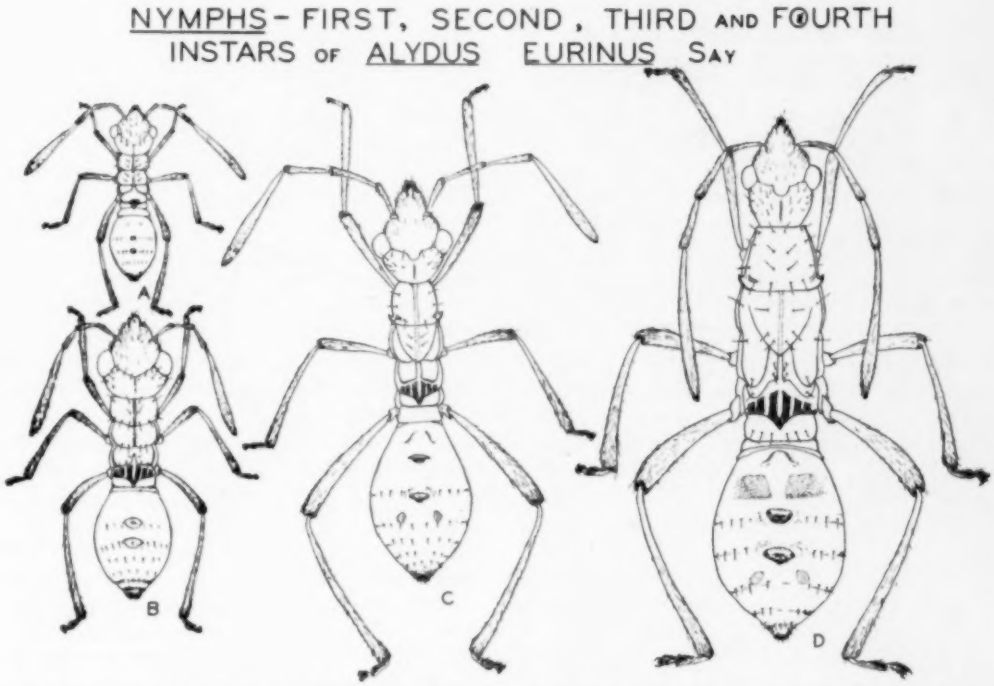

FIG. 4.—Dorsal aspect (×7); A, first, B, second, C, third and D, fourth instar nymphs of *Alydus eurinus* Say.

the scent glands. Wing pads beginning to show (Fig. 4, B).

The third instar averages 5 to 6 millimeters. Color somewhat similar to that of the second instar. First abdominal segment reddish-brown; second abdominal segment white on anterior part and reddish on posterior border. Wing pads with reddish median border and paler dividing line. There are two velvety spots just behind and lateral to the second scent-gland tubercle (Fig. 4, C).

The fourth instar individuals range in length from 6 to 7 millimeters. Color simi-

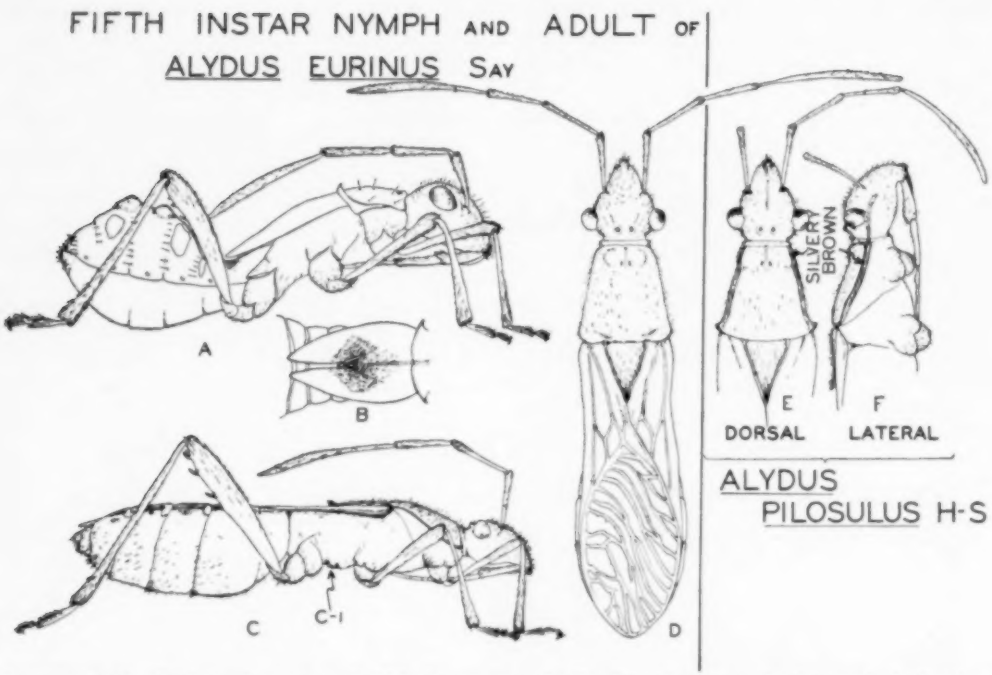

FIG. 5.—(×3). A, lateral aspect of fifth instar nymph; B—Dorsal aspect of wing pads indicating the velvety area; C—Lateral aspect of adult, C-1—Location of ostiolar scent gland in front of the hind coxa; D—Dorsal aspect of adult; (A-D—*Alydus eurinus*). E & F—Dorsal and lateral aspects of *A. pilosulus*.

lar to that of the third instar; a pair of dark velvety areas appearing on the dorsal side of the abdomen anterior to the first pair of scent-gland tubercles. Mesowing pads almost covering metawing pads. Three small black spines appear on the femur of the metathoracic leg (Fig. 4, D).

The fifth instar averages 7 to 11 millimeters. Color dark-brown to lighter yellowish-brown, with a reddish tinge in places; median line on prothorax pale, bordered with dark-brown; central region of prothorax, of mesothorax, and of mesothoracic wing pads with velvety dark-brown triangular areas; posterior point of scutellum white. Abdomen with four velvety spots; basal segment reddish-brown with narrow white margin on posterior edge; eighth segment with small dark chitinized area on the central dorsal part; ninth segment dark-brown to black dorsally; tenth segment tubular, black. Scent-gland tubercles prominent, located between the third and fourth and the fourth and fifth segments. Femur of metathoracic leg usually with four spines along the distal half of the inner edge (Fig. 5, A and B).

The adult is slender, elongate, 10 to 14 millimeters in length, with sides nearly parallel. Eyes are prominent; head is about equal in width to the thorax. The color is almost solid black, with a brownish tinge in places. On the central dorsal side of the abdomen beneath the wings is a fiery red area, which shows when the adult takes flight (Fig. 5, C and D).

LIFE HISTORY.—The data on life history are based on observations made in the vicinity of Richmond and on insects reared in the laboratory. There were two full generations, with some overlapping in the field. There is probably also a partial third generation in eastern Virginia. Efforts made to find adults in hibernation failed. From 70 to 94 per cent of eggs collected in the fall of 1930 and 1931, some of which were carried over the winter in the insectary at Richmond and some at Blacksburg, hatched in the spring of 1931 and 1932, respectively. Nymphs and empty eggshells were obtained from soil and debris collected in late April 1931 and early May 1932, in an area where females were known to have been present the previous fall. These facts indicate that the insect passes the winter in the egg stage.

The earliest dates on which adults were collected in the field were as follows: April 22 in 1920, at Petersburg; and May 22 in 1929, May 2 in 1930, May 18 in 1931, and May 11 in 1932, at Richmond. Adults were fairly numerous, as a rule, by the last week in May; and laboratory studies indicate that first generation adults were in the field until approximately the middle of September. Second generation adults began appearing about the first of August and were present until December. There was considerable overlapping of the two generations, so that adults were present in the field continuously from May until December

Observations on a few females in the laboratory showed a preoviposition period of 11 to 26 days, averaging 20.9 days. Females collected in the field oviposited for an average of 7 days. Females reared in the laboratory oviposited over a maximum period of 23 days, the average being 15 days. The average number of eggs deposited per female was 27.4 and the maximum 49. Maximum egg deposition took place at temperatures of 75 to 80° F., or higher, and during the hottest part of the day. A maximum of 10 eggs per day was laid by a caged female. Observations on gravid females in the field and cage records indicate that oviposition of first generation adults reached the maximum in June and that of the second generation in late July and in August.

The average length of life of females in the laboratory was 40.1 days and the maximum 54 days. For males the average was 42 days and the maximum 51 days.

Studies were made in the insectary on the incubation period of eggs during the years 1929 to 1932, inclusive. Over 800 eggs were used. Eggs studied were kept on sand in glass tubes. The incubation period for eggs laid from May 7 to August 17 ranged from 8 to 18 days. The average period for first and second brood eggs deposited on different dates ranged from 10.7 days for eggs deposited June 30 to August 3, 1930, to 16.3 days for eggs deposited May 7 and 8, the same year. Eggs deposited on August 17, 1930, hatched in 15 days. First brood eggs laid May 29 to June 21, 1931 averaged 13.6 days; first brood eggs laid May 19 to 25, 1932 averaged 15.5 days. Of 501 eggs observed in the insectary in 1929 and 1930, a total of 86.2 per cent hatched. Of eggs deposited by gravid females collected in the field, 91.3 per cent hatched in 1929 and 89.7 per cent in 1930.

The insect molts five times during development and, therefore, has five nymphal instars. The length of the instars is given in table 1. The total time required for development from hatching to adult ranged from 44.8 to 49.5 days for females and from 41.1 to 49.11 days for males. During the summer the time required for a complete life cycle, from egg to egg, was about 10 weeks. The time was somewhat longer in the fall or spring. During the hibernating period, the time from egg to egg may be extended to as much as 8 to 9 months.

DESCRIPTIONS. *Alydus pilosulus*.—The eggs are of the same general shape as those of *A. eurinus*. They are smaller, smooth, shiny, silvery when first deposited, turning to golden bronze later. Nymphs of all stages are very similar to *A. eurinus* but may be distinguished by the color, which is reddish-brown generally. The color of the first instar *A. pilosulus* is lighter than the first instar of *A. eurinus*. The head, prothorax, and mesothorax of *A. pilosulus* are darker than the abdomen. Anterior two-thirds of metathorax very dark-brown velvety on the dorsal side; posterior part reddish with white point in center. First segment of abdomen reddish. The abdomen of the second and third instar is glistening, with a copper-red tinge when distended and with an internal dark spot visible on the right-hand side. In some specimens, the fourth instar shows a pale line along the sides just below the level of the border of the prothorax and this line may extend down the sides of the head below the eyes. Color of thorax and wing pads of the fifth instar reddish-yellow; head darker; legs reddish except first tarsal joint, which is white at base and dark at tip, and last tarsal joint dark; abdomen dark, with basal segment light, greenish. The pale border line on thorax and side of head is present similar to the fourth instar. The adult of *A. pilosulus* is distinguished from *A. eurinus* by the color, which is lighter, definitely brown. There is also a silvery brown border line on thorax and sides of head. The thorax is somewhat narrower and the posterior lateral angles decidedly pointed (Fig. 5, E and F).

LIFE HISTORY.—Notes on the life history of *Alydus pilosulus* were made with

Table 1.—Length of instars of *Alydus eurinus*.

Date of Hatching	Number of Individuals	Length of Instar in Days		
		Maximum	Minimum	Average
1929	*First Instar*			
July 3 to 16	124	5	2.5	3.4
August 2 to 14	8	5.5	3.7	4.5
1930				
May 23 to August 25	57	13	2.5	4.9
1929	*Second Instar*			
July 3 to 16	64	17.5	8.2	13.9
August 2 to 14	8	14	6	10.1
1930				
May 23 to August 25	23	20	3	8.0
1929	*Third Instar*			
July 3 to 16	58	16	4	8.7
August 2 to 14	6	15.5	5	10.2
1930				
May 23 to August 25	18	19	3.5	9.2
1929	*Fourth Instar*			
July 3 to 16	54	14.5	6	9.2
August 2 to 14	3	11	5.5	8.8
1930				
May 23 to August 25	18	20	6	8.9
1929	*Fifth Instar*			
July 3 to 16	45	22	8	14.0
August 2 to 15	2	12	11	11.5
1930				
May 23 to August 25	10	19	10	13.8

those on *A. eurinus*. Little difference was noted in the seasonal history of the two insects. Both insects have two generations and probably a partial third, in Virginia, and both pass the winter in the egg stage. The preoviposition period for 17 females ranged from 10 to 25 days and averaged about 18 days. The maximum time of oviposition was 59 days. The average was 21 days for females reared in the insectary. Females collected in the field oviposited for a much longer period, the average time being about 6 weeks. The average number of eggs deposited per female in 1929 was 38.3 and the maximum 67. The average length of life of females in the laboratory was 42 days and the maximum 57; for males the average was 43.6 and the maximum 59 days.

The average incubation period for eggs deposited on different dates ranged from 9.6 days for eggs deposited in July 1930 to 23.7 days for eggs deposited September 23, 1930. Eggs deposited June 15 to July 24, 1931 averaged 10.6 days; a few laid May 24 and 25, 1932 averaged 14.9 days. Like *Alydus eurinus*, *A. pilosulus* has five instars. The average time required for development by nymphs hatching on different dates ranged from 37.5 to 39.2 for females and from 35.8 to 40.7 for males. This was an average of about one week less in most cases than for *A. eurinus* under similar conditions. The studies did not indicate that the time required for the complete life cycle for *A. pilosulus* differed essentially from that for *A. eurinus*, which ranged from about 10 weeks in summer to as much as 8 to 9 months during hibernation.

NATURAL ENEMIES.—No parasites of eggs, nymphs or adults have been observed in these studies. Ants readily attack the eggs and it is believed destroy large numbers.

SUMMARY.—The broad-headed bugs, *Alydus eurinus* and *A. pilosulus*, are widespread in Virginia, feeding on nectar glands, stems and seedpods of practically all legumes, both cultivated and wild. Of cultivated crops, the lima bean, soybean, and cowpea are most seriously injured. The germination of the injured seeds is reduced and the vigor of the plants developing from these seeds is lowered. There are two full generations and probably a partial third generation of each of these insects in eastern Virginia. Both insects pass the winter in the egg stage. Life history data for both species are included.—1-26-43.

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Survey of Tobacco Carriers for Stored-Tobacco Insects[1]

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For a number of years the tobacco industry has been concerned about the infestation of stored tobacco in transit. American tobacco exporters ship annually over 300 million pounds of flue-cured and other types of domestic tobaccos to many parts of the world, and importing firms bring into this country each year from 40 to 60 million pounds of foreign-grown types. This large volume of traffic involves moving the tobacco in various carriers, the principal types of which are ships, railway cars, and motor trucks.

From October 1 to December 31, 1939, a survey was conducted at the Hampton Roads ports of Norfolk and Newport News, Va., to determine the importance of these carriers in disseminating stored-tobacco insects. The principal insects sought, and the only tobacco insects found, were the tobacco moth, *Ephestia elutella* (Hbn.), and the cigarette beetle, *Lasioderma serricorne* (F.).

Methods of Conducting the Survey.—Ships taking on domestic tobacco for export were inspected, and data regarding the cargo were obtained from the appropriate ship's officer. These recorded data included name of the ship, agent, number of hogsheads or cases to be loaded, destination, date of previous handling of tobacco, date of last fumigation of ship, capacity of ship, and items of cargo other than tobacco that would serve as host foods of the insects. Before the tobacco was loaded, the ship holds were examined, including the walls, the wood dunnage, and all cracks and crevices that might conceal or provide shelter for tobacco insects.

Ships bringing in lots of foreign-grown tobacco were inspected through the cooperation of the importers and steamship companies. These ships were boarded immediately after they had docked, and the tobacco and other cargo were inspected. In addition to the information as previously listed for ships transporting domestic tobacco, data were obtained regarding the number of bales of imported tobacco, type, point of origin, and date of shipment. Bales of tobacco, dunnage, and walls of the ship's holds were also examined for insects.

In the examination of railway cars used for moving domestic tobacco, all inspections were made either at the time the cars were unloaded or immediately thereafter. Data regarding point of origin, date of shipment, number of hogsheads, and age of tobacco were obtained from warehouse officials at the port terminals. The car number and capacity were recorded, an inspection was made of the side and end walls, ceiling, and floor of the car, and a list was made of any remnants of host foods other than tobacco present from previous shipments.

Fig. 1.—Method of transporting hogsheads of tobacco by motor truck from point of origin to port terminal. Note that the canvas covering is being pulled off prior to driving on the pier for unloading. Norfolk, Va., 1939.

The inspection of motor trucks transporting domestic tobacco presented a rather difficult problem, since no advance information was available as to their exact time of arrival. On arrival at the docks or tobacco warehouses at port terminals the following information was obtained: Name and address of trucker and shipper, point of origin of shipment, destination, number of hogsheads, and crop and district. At the time of unloading, inspections were made of the sides of the hogsheads and on and beneath the tarpaulin covers before and after they were removed from the truck (Fig. 1). After the tobacco had been unloaded, the floor boards and sides of the truck were examined, and records were made of the presence of tobacco scraps and any remnants of other host

[1] Eastern Branch Program. New York, November, 1942.

foods of the insects from previous shipments.

RESULTS OF SURVEY.—The pertinent results of the survey of 53 ships taking domestic tobacco for export to foreign countries are presented in table 1. These data show that during the period of investigation 35,427 hogsheads and 22,770 cases of domestic tobacco were shipped from the Hampton Roads, Va., ports (Fig. 2) to the following countries: England, Ireland, Holland, Belgium, Norway, Sweden, Denmark, China, Japan, Argentina, Brazil, Uraguay, Phillipine Islands, Australia, New Zealand, Java, Siam, and Malaya. The hogsheads of tobacco each contained about 1000 pounds and the cases each about 600 pounds

Table 1.—Summary of results of a survey of ships loading domestic tobacco at the ports of Hampton Roads, Va., October to December 1939.

MONTH	NUMBER OF SHIPS	DESTINATION OF TOBACCO	NUMBER OF UNITS Hhds.	Cases	FOODS OTHER THAN TOBACCO FOUND ON SHIP	INSECTS FOUND
October	10	Java, Holland, England, China, Denmark	11,244	3,742	Soybean meal, cottonseed products, cacao beans, flour	None
November	23	Argentina, Holland, China, Belgium, Norway, Denmark, Australia, Siam, Java, Manila, Brazil, England, Sweden, Malaya, Ireland	14,476	7,629	Cacao beans, dried figs, corn, wheat, bonemeal, peanuts, copra, tapioca, linseed, Brazil nuts, cottonseed products, black pepper	None
December	20	England, Holland, Japan, China, Java, Denmark, Norway, Belgium, Manila, Australia, New Zealand, Malaya, Uraguay, Argentina	9,707	11,399	Cinnamon, corn, cacao waste, soybeans, potato flour, wheat, linseed cake, beans, melon seed, wheat flour, scrap tobacco, cacao beans, pepper, tapioca flour, bonemeal, sago flour, copra, cottonseed products, peanuts	

Although no tobacco insects were found on the ships inspected, the following host foods which might serve as sources of infestation were found either in holds in which tobacco was loaded or in adjoining holds on the same ship: Tapioca, copra, cacao beans, black and white pepper, wheat, wheat flour, peanuts, linseed, cottonseed products, potato flour, soybeans, sago flour, dried figs, raisins, corn, currants, cinnamon, cacao waste, bonemeal, linseed cake, and tobacco scraps. Such materials present in the holds of ships exporting tobacco might carry the source of new infestations for fumigated tobacco or any tobacco free of insects.

The results of the inspection of ships bringing in imported tobacco to the Virginia ports are presented in table 2. During the period of investigation a total of 16 ships discharged 313,043 bales of tobacco at these ports (Fig. 3). Tobaccos from the following countries were represented in the importations: Turkey, Greece, Union of Socialist Soviet Republics, Bulgaria, Italy, Syria, and Rhodesia. Adults and larvae of the tobacco moth or of the cigarette beetle were found in 15 out of the 16 shipments inspected, the infestations in most instances being heavy. In many cases ships discharging imported tobacco carried several host foods of the insects in the holds in which tobacco was carried or in adjoining compartments on the ship. Table 2 shows also that shipments of imported tobacco were in transit for periods of from 21 to 46 days. The average was 33.5 days. These periods, especially in the early fall months when the weather is warm, are of sufficient length for the development of infestations in transit.

Results of the survey of railway cars bringing tobacco from inland points to the ports for storage or export are given in table 3. No cigarette beetles were found in any of the railway cars inspected, but 9, or 6.16 per cent, of the 146 cars examined contained live tobacco moths on arrival at the ports. In October 13.04 per cent and

in November 5.66 per cent of the cars were found infested; no insects were found in December. All shipments in which tobacco moths were found originated at inland points in North Carolina and Virginia.

In view of the fact that the tobacco in these cars was from the 1939 crop that had previously been run through the redrying machines, it appears that the moths found flew into the cars at tobacco warehouses prior to the loading. No moths were found in railway cars in December, and fewer in November than in October, indicating that the lower temperatures in November retarded activity of the moths at point of origin. Many of the railway cars contained remnants of host foods of the insects, other than tobacco from previous shipments, scattered around on the car floors or in crevices in side and end walls. The results of these inspections of railway cars indicate that this type of carrier may be an important factor in the development of tobacco moth infestations in uninfested or fumigated storage warehouses at port terminals. Figure 4 shows a hogshead of tobacco being unloaded from a car, and the close proximity of the car to the open door of the warehouse shows how easily moths could fly from a car into the warehouse.

During the period of the survey a total of 59 motor trucks were examined for stored-tobacco insects, and the results were negative as far as insects were concerned. As was noted in the inspections of ships and railway cars, however, many of the trucks examined contained tobacco scraps and host foods other than tobacco.

DISCUSSION.—To reduce the danger of insect infestations to tobacco in shipment, originating from host foods of the insects carried as cargo in ships, it appears that every effort should be made to place such food materials in other holds than those into which the tobacco is loaded, and any remnants of these materials present in holds in which tobacco is to be carried should be gathered up and destroyed prior to the loading. It was observed that hogsheads of tobacco from several sources are often placed in the same hold on the ship. This should be avoided, as it may subject fumigated or uninfested tobacco to new infestation in transit.

It was observed that in some instances domestic tobacco for export was loaded in ship holds from which imported tobacco infested with insects had just been removed. Domestic tobacco shipped out under such conditions is likely to become infested in transit.

In many instances ships discharging imported tobacco were docked either alongside of, or in close proximity to, ships loading domestic tobacco for export. If the imported tobacco is infested, such a pro-

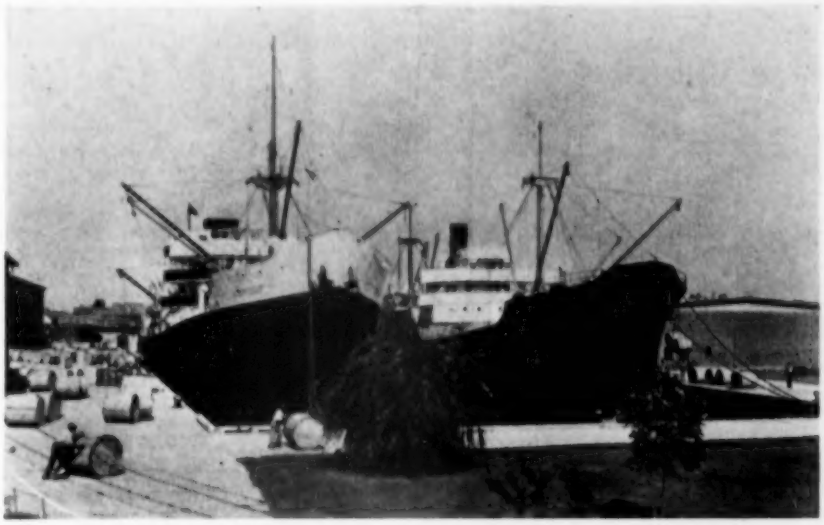

FIG. 2.—Hogsheads of domestic tobacco each containing about 1000 pounds being loaded for export. Norfolk, Va., 1939.

Table 2.—Summary of results of a survey of ships used for importing foreign-grown tobacco at the ports of Hampton Roads, Va., October to December 1939.

Month	Number of Ships	Origin of Shipment	Number of Days Shipment in Transit	Number of Bales of Tobacco in Shipment	Foods Other Than Tobacco Found on Ship	Tobacco Insects Found
October	4	Bulgaria, Greece, Turkey	31–45	26,360	Dried figs, acorns, currants	33 *Ephestia elutella* adults. 10 *E. elutella* larvae. 1 *E. elutella* pupa. 5 *Lasioderma serricorne* adults.
November	9	Bulgaria, Greece, Turkey, Italy, Rhodesia, Syria, Russia	21–42	181,187	Currants, figs, cacao, paprika, hazelnuts, almonds, filberts, lemon peelings, birdseed, orris root, fruit pulp, poppy seed	30 *E. elutella* adults. 27 *E. elutella* larvae. 1 *E. elutella* pupa. 67 *L. serricorne* adults. 47 *L. serricorne* larvae.
December	3	Bulgaria, Greece, Turkey	21–46	105,496	Almonds, poppy seed, canary seed, filberts, rape seed, mustard seed, chestnuts, figs, vetch seed, beans, paprika, raisins	40 *E. elutella* larvae. 6 *L. serricorne* adults. 8 *L. serricorne* larvae.

cedure offers conditions favorable for the development of insect infestations in the domestic tobacco. Infested imported tobacco sometimes remained on piers from 2 to 5 days before being moved to a storage warehouse. This practice would subject to infestation domestic tobacco on piers awaiting export, and might also be the source of infestation of ships being loaded in the vicinity. It was noted also that imported tobacco is sometimes shipped from point of origin to an intermediate point on one ship and then transshipped to its destination on another. One shipment of infested tobacco might thus be the means of developing infestations in more than one ship. Cargoes of imported tobacco are often from two or more countries and are stacked in the same hold of the ship. This method of handling the tobacco might infest the entire cargo if one lot is infested.

The finding of live tobacco moths in railway cars on arrival at port terminals shows that this type of carrier may be an important factor in the development of new infestations in uninfested storage warehouses or of causing reinfestation of fumigated warehouses.

The transportation of tobacco in motor trucks did not appear to be an important factor in disseminating stored-tobacco insects.

Table 3.—Summary of results of inspection of railroad cars showing the relative percentages of tobacco moth infestation by months. Norfolk and Newport News, Va., October, November, December, 1939.

Month	Railroad Cars Inspected	Cars Containing Live Moths	Per Cent of Cars Infested
October	46	6	13.04
November	53	3	5.66
December	47	0	0.0
Total	146	9	6.16

Summary.—From October 1 to December 31, 1939, a survey was conducted at the Hampton Roads ports of Norfolk and Newport News, Va., to determine the importance of tobacco carriers (ships, railway cars, and motor trucks) in disseminating stored-tobacco insects, principally the tobacco moth and the cigarette beetle. During the period of survey a total of 69

ships, 146 railway cars, and 59 trucks were inspected.

Although no tobacco insects were found on any of the ships taking domestic tobacco to foreign countries, a large number of host foods of the insects, other than tobacco, were found either in holds in which tobacco was placed or in adjoining holds on the ships. It was noted that tobacco from several sources was often placed in the same hold of a ship, thereby subjecting fumigated tobacco to possible infestation in transit. Practically all the foreign-grown tobacco brought in during the period of survey was infested with the tobacco moth and the cigarette beetle. Domestic tobacco for export was sometimes placed in ship holds from which infested imported tobacco had just been removed, and ships bringing in imported tobacco were often docked close to ships loading domestic tobacco for export. Imported tobacco frequently remained on piers from 2 to 5 days prior to shipment by railroad to its destination.

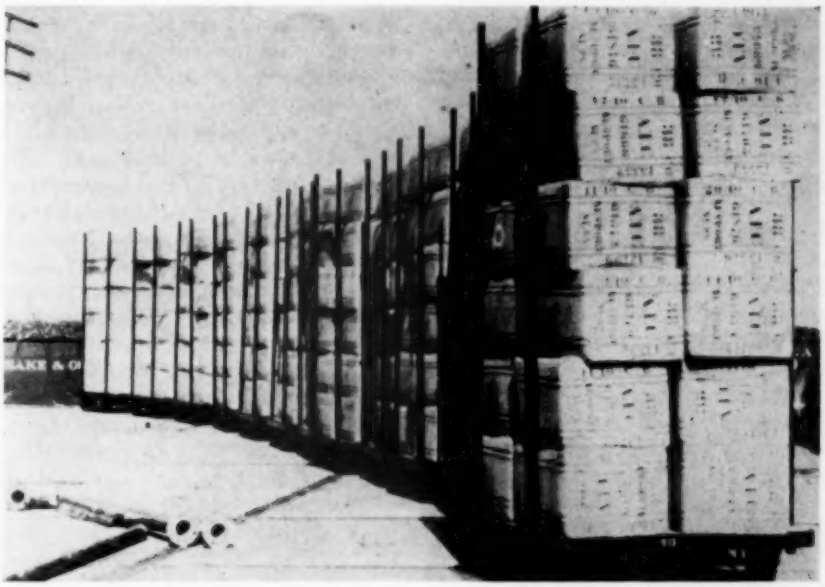

FIG. 3.—Imported cigarette tobacco loaded from ships or railway cars on portable flats for transportation to storage warehouses. Newport News, Va., 1939.

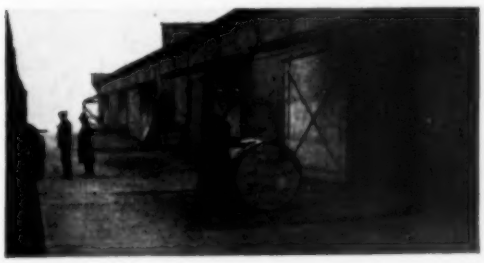

FIG. 4.—Hogshead of tobacco being unloaded from railroad car and placed in storage at port terminal warehouse prior to export. Norfolk, Va., 1939.

Although no cigarette beetles were found in any of the railway cars inspected, 9, or 6.16 per cent, of the 146 cars examined contained live tobacco moths on arrival at port terminals. Apparently the moths had flown into the cars at the time of loading, showing that this type of carrier may be an important factor in the development of new infestations in uninfested storage warehouses or of causing reinfestation of fumigated warehouses.

During the period of survey a total of 59 motor trucks were examined for stored-tobacco insects, but this type of carrier appears to be of little importance in disseminating stored-tobacco insects.—12-18-41.

Fumigation of Tobacco at Reduced Pressures

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Although fumigation at reduced pressures to control insect pests is not new, it was only in recent years that it came into extensive use in the tobacco industry. At the present time most imported tobaccos are fumigated in vacuum upon arrival at the port of entry, or at the manufacturing centers prior to being placed in storage. An increasing volume of domestic tobacco is being treated similarly before it is exported.

Early work with fumigants at reduced pressures was reviewed briefly by Lindgren (1936) and Monro (1941) gives a detailed discussion of this subject.

Hydrocyanic acid has been widely used for vacuum fumigation of tobacco, and methyl bromide also has been tested with favorable results. The latter can be used for treating nursery stock and many commodities which are injured by hydrocyanic acid. In addition, it has proved highly toxic to stored tobacco insects. Experimental work with hydrocyanic acid and methyl bromide in the fumigation of tobacco has been carried on at the Tobacco Insect Laboratory in Richmond, Va., for several years.

Recent work by O'Kane & Smith (1941) with a new fumigant, 1,1-dichloro-1-nitroethane, showed it to be effective against some species of insects attacking stored products. It was thought that this material might also be effective against the pests of stored tobacco.

The work reported in this paper was undertaken to obtain data on the most effective dosages of these fumigants and to compare the relative toxicity at reduced pressures.

Fumigants Tested.—The fumigants used in these experiments were liquid hydrocyanic acid, methyl bromide, and 1,1-dichloro-1-nitroethane.

Hydrocyanic acid (HCN) is a colorless, volatile liquid with a molecular weight of 27.02. It has a density of 0.6876 at 20°/4° C., and it is miscible with water, alcohol, and ether. The commercial grade used in this work contained 97.7 per cent hydrocyanic acid, as shown by the certified chemical analysis of the manufacturer.

Methyl bromide (CH_3Br) is a colorless gas with a molecular weight of 94.94. It has a density of 1.732 at 0°/0° C., and it is only slightly soluble in water, although very soluble in alcohol and ether.

The third fumigant, 1,1-dichloro-1-nitroethane ($CH_3CCL_2NO_2$), is a colorless liquid with a molecular weight of 143.9454. It has a density of 1.4153 at 20° C. The flash point is 57.78° C. and the boiling point is 124° C. It is insoluble in water. The material has sufficient odor to make known its presence, and it also causes some smarting of the eyes. However, the two "air-washings" given the tobacco in these tests removed much of the residual gas, and the treated tobacco was handled without discomfort to the operator.

Equipment.—The fumigation equipment used in these experiments consisted of a steel vacuum chamber, rectangular in shape, measuring 50 by 36 by 32 inches, with a total volume of 33 cubic feet (Fig. 1).

The pressure in the chamber was reduced by means of an electrically driven, 2-stage, dry vacuum pump, capable of producing a partial vacuum equivalent to 1 inch of absolute pressure on a mercury gauge in 10 to 15 minutes. A recording vacuum gauge and a recording thermometer were located on the instrument panel of the chamber. Measuring cups for dispensing small quantities of the fumigants were fitted to the chamber. The one used for measuring hydrocyanic acid had a glass barrel calibrated in ounces. The coiled copper tubing leading from the measuring device to the vacuum chamber was enclosed in a small water bath (Fig. 1). When filled with hot water, this bath served as a volatilizer. The same apparatus was adapted for use with 1,1-dichloro-1-nitroethane by devising a new set of graduations for the cup. The measuring device used for methyl bromide had a glass barrel marked in cubic centimeters. There were approximately 36 inches of copper tubing between the measuring cup and the point of entrance into the chamber of the fumigant, and at room temperatures this was sufficient to give complete vaporization of the methyl bromide.

[1] Eastern Branch Program, New York, November, 1942.

Imported cigarette tobacco was used in these experiments, tightly compressed in bales 20 by 25 by 15 inches, each weighing about 140 pounds. All bales of tobacco used were of the same age and grade.

The experimental equipment was located in a large laboratory where the air temperature remained about 70° to 80° F.

PROCEDURE.—Identical procedures were followed in testing each of the three fumigants. Tests of each material were replicated six times, at dosages of 4, 3, 2, and 1 pound per 1000 cubic feet. The duration of exposure was 3 hours under a sustained vacuum, followed by a postfumigation period of 72 hours at normal pressure. This postfumigation exposure was included because it has been shown by Johnson *et al.* (1938) that hydrocyanic acid gas was adsorbed to the surfaces of

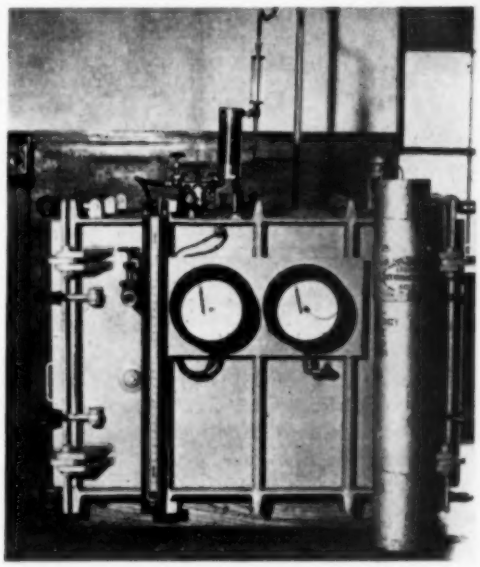

FIG. 1.—Experimental vacuum chamber showing the instrument panel containing thermograph, recording vacuum gauge, and mercury manometer. Note the apparatus for handling small dosages of hydrocyanic acid; also the measuring cup and water-bath volatilizer.

the commodity being fumigated (baled cotton) and that one or two "air-washings" did not lower appreciably the amount of "sorbed" gas. Other work, by Reed & Livingstone (1938), has indicated that in order to obtain the full effect of the fumigant it is necessary to leave the test insects exposed to this "sorbed" gas for about 72 hours.

The test insects were reared under controlled conditions and were comparable for all tests. Lots of 25 well-grown larvae of the cigarette beetle, *Lasioderma sericorne* (F.), were placed at depths of 1, 3, 5, 7, and 9 inches in the bales of tobacco by means of a steel test spike described by Reed *et al.* (1936).

One spike was inserted into each of the two bales used in a test, and this gave a

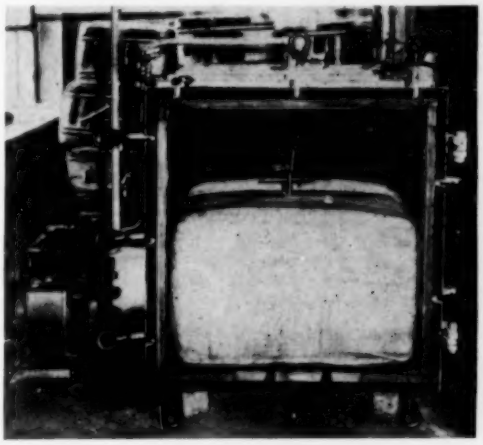

FIG. 2.—Bales of imported cigarette tobacco with steel test spikes in place preparatory to fumigation at reduced pressures. The electric motor and vacuum pump are also shown.

total of 250 larvae exposed per test and 1500 for each treatment. The check for each replicate consisted of 5 lots of 25 larvae placed in an untreated bale under conditions identical with those of the treated lots (Fig. 2).

The two bales treated were placed in the chamber, and the pressure was reduced inside to about 29 inches below normal on the mercury gauge, or to an absolute pressure of about 1 inch of mercury. This work was done at about 60 feet above sea level. When the fumigant was introduced, the pressure increased slightly, usually about one-half inch. Three hours after the introduction of the gas, the vacuum breaker valve was opened and air allowed to enter until the pressure increased to normal. This valve was then closed, the vacuum pump started, and the air-gas mixture evacuated until an absolute pressure of about 2 inches was reached. The vacuum breaker valve was opened again and the pressure allowed to return to normal. This provided two "air-

washings" and removed all the fumigant from the space in the chamber and some of it from the tobacco. The bales were then removed from the chamber and held in the laboratory for about 72 hours before the test spikes were removed. Check lots of insects received exactly the same treatment except for exposure to the vacuum and the fumigant.

The temperature of the tobacco ranged from 70° to 80° F., and the moisture content was about 12 to 13 per cent at the time of fumigation.

ranged from 4 to 100 per cent. It ranged from 44.4 to 99.2 per cent among the replicates. A seventh replicate at this concentration was conducted to find out whether the variation was due to some unrecognized factor, but the results were similar to those of the previous tests.

Hydrocyanic acid gave the next best results. Complete mortality among the test insects was produced by only the 4-pound dosage, but the effectiveness of this material decreased only slightly with each drop in concentration. A dosage of 3

Table 1.—Average mortality of larvae of the cigarette beetle following fumigation with hydrocyanic acid, methyl bromide, and 1, 1-dichloro-1-nitroethane at reduced pressure. Richmond, Va., 1941.

Fumigant	Pounds per 1000 Cu. Ft.	Number of Larvae Treated	Per Cent Mortality at Indicated Depth in Tobacco					All Depths
			1 inch	3 inches	5 inches	7 inches	9 inches	
Hydrocyanic acid	4	1497	100	100	100	100	100	100
	3	1500	100	100	99.67	99.67	100	99.87
	2	1499	100	100	99.67	99.33	100	99.80
	1	1500	99.67	98.67	95.67	94.67	97.33	97.20
Methyl bromide	4	1499	100	100	100	100	100	100
	3	1500	100	100	100	100	100	100
	2	1500	100	100	100	100	100	100
	1[1]	1734	73.10	86.00	91.41	92.60	91.40	86.90
1,1-dichloro-1-nitroethane	4	1500	99.67	100	99.00	99.00	99.33	99.40
	3	1500	99.33	99.67	99.00	98.00	99.00	99.00
	2	1500	93.00	92.67	91.33	89.33	87.33	90.73
	1	1493	72.82	75.25	61.33	61.67	58.44	65.90

[1] Seven replicates for this dosage.

At the expiration of the postfumigation period the test spikes were removed from the tobacco and the insects examined. Each lot of larvae was placed in a small covered glass dish, and daily records of mortality were obtained for 7 days. The mortalities of test insects were taken on the day of maximum revival for the treated insects, and on the day of removal from the bale for the check lots.

RESULTS.—The average mortality for six replicates of each dosage for hydrocyanic acid, methyl bromide, and 1,1-dichloro-1-nitroethane are given in table 1.

From these data it appears that, of the fumigants tested, methyl bromide was the most toxic to cigarette beetle larvae, with no insects surviving treatment at dosages of 4, 3, and 2 pounds per 1000 cubic feet. However, the survival at the 1-pound dosage varied considerably. In one case the mortality in the five test lots in one spike pounds per 1000 cubic feet killed all test insects in four of the six replications and 2 pounds produced complete mortality in three replications. The 1-pound treatment permitted some insects to survive in all replicates, but it killed an average of 97.2 per cent of all thus treated.

The results obtained with 1,1-dichloro-1-nitroethane showed that a dosage of 4 pounds per 1000 cubic feet killed all test insects in three of the six replicates, and the average mortality was 99.4 per cent. The 3-pound dosage killed 99 per cent of the test insects, but in none of the replicates at this or at lower concentration were all the test insects killed. With 2 pounds the average mortality dropped to 90.73 per cent, while the average of 65.9 per cent for the 1-pound dosage was the lowest for any treatment.

In the tests with hydrocyanic acid and with methyl bromide there appeared to be no correlation between the mortality of

the insects and their depth in the bales of tobacco at the time of fumigation. The 1,1-dichloro-1-nitroethane, however, did not seem to penetrate the tobacco as well as did the other two fumigants, and there was a tendency for it to be less effective at the greater depths in the tobacco.

The effect of the partial vacuum alone on the test insects was not pronounced. The results of seven tests using the same procedure described above, but without applications of gas, showed an average mortality of 14.12 per cent for 1742 larvae so treated, compared with 3.89 per cent for the 872 larvae used in the check lots.

The average mortality for all the checks used with the fumigation treatments was 2.51 per cent.

CONCLUSIONS.—The foregoing tests showed that at dosages of 4 pounds per 1000 cubic feet methyl bromide and hydrocyanic acid were about equally effective against larvae of the cigarette beetle. Methyl bromide was more toxic than hydrocyanic acid in the treatments using 3 and 2 pounds of fumigant, while hydrocyanic acid was more effective at the 1-pound dosage. The 1,1-dichloro-1-nitroethane proved less toxic than methyl bromide and hydrocyanic acid at these concentrations. This gas is comparatively new in the field of tobacco fumigation, and these tests indicate that it can be used safely on tobacco. These tests also failed to show that methyl bromide had any deleterious effects on the imported cigarette tobaccos. Fumigants which might combine with the waxes, fats, and oils in the tobacco leaf would be likely to affect the aroma of the tobacco and the smoke. The need for further work with 1,1-dichloro-1-nitroethane and methyl bromide is indicated by these tests.

SUMMARY.—Experimental fumigations of imported cigarette tobacco were made at reduced pressures, using hydrocyanic acid, methyl bromide, and 1,1-dichloro-1-nitroethane. The 12 treatments, replicated 6 times, involved the use of the 3 fumigants, each at rates of 4, 3, 2, and 1 pound per 1000 cubic feet. Well-grown larvae of the cigarette beetle were used for test insects. These were placed in the tobacco by means of steel test spikes. The bales were fumigated in a small vacuum chamber, equipped with instruments for recording the air temperature and air pressure obtained in it, and fitted with suitable apparatus for accurately measuring small quantities of the fumigants. All exposures in the vacuum chamber were for 3 hours under an absolute pressure of 1 to 1.5 inches of mercury, followed by a post-fumigation period of 72 hours in the laboratory. The insects were held for 7 days after removal from the tobacco, and daily observations were made on survival. The data showed that the average mortalities produced by the methyl bromide treatments using 4, 3, 2, and 1 pound per 1000 cubic feet were 100, 100, 100, and 86.9 per cent, respectively. Hydrocyanic acid yielded averages of 100, 99.87, 99.80, and 97.20 per cent, respectively, for the 4-, 3-, 2-, and 1-pound treatments, while for 1,1-dichloro-1-nitroethane the average mortalities were 99.40, 99.00, 90.73, and 65.90 per cent, respectively, at these concentrations.—1-2-43.

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WAR BONDS ARE STILL ON SALE!

Undercooling and Freezing of Insects[1,2]

L. P. Ditman, George B. Voght,[3] and Dwight R. Smith

This paper constitutes the second of a series of reports on cold resistance in insects. The experiments discussed here were primarily devoted to comparing various techniques for determining undercooling and freezing points of the species used in unfreezable water studies already reported (Ditman *et al.* 1942). Comparisons were made of the types of apparatus described by Robinson (1928), by Salt (1936), and by Ditman & Weiland (1941). During these studies, observations were made on the lethal effect of cold on the species of insects used and the application of these results to field conditions is discussed.

The authors, in a preceding paper (Ditman *et al.* 1942), and Salt (1936) have implied that, for insects that do not survive undercooling and subsequent freezing, determinations of undercooling points provide definite information on the lethal low temperature. This class comprises the largest group of insects in the temperate regions of North America, and it is with this group that this work is primarily concerned. Lethal low temperatures of the smaller class of extremely cold-hardy insects that survive undercooling and freezing can be determined only by direct exposure to low temperatures and working out the cold intensity-time relationship.[4] The non-hibernating, non-cold-hardy insects that succumb to low temperatures without freezing, such as discussed by Payne (1926) were not used in this work.

Methods.—Determinations of undercooling points were made at various refrigeration temperatures from just below the undercooling range of the species used to −70 degrees[5] with the glass insect holder of Robinson, the cork holder of Siegler (1931), later modified by Ditman & Weiland, and the rubber holder of Salt (Fig. 1). Freezing points were determined by inserting the thermocouple into the abdominal region of the insect body and freezing it at the highest possible refrigerator temperature in a cork holder.

The apparatus for recording temperatures has been described by Ditman and Weiland. All determinations were made under dry conditions in order to avoid seeding by external ice crystals as described by Salt. Experiments by the authors on the effect of external water, particularly water condensed on cold holders, confirm the observations of Salt. This condition is of considerable importance in interpreting laboratory results and will be discussed later.

Results.—Observed undercooling and freezing points for the various species are shown graphically in figures 2 and 3. Each pair of points on these graphs represents the average observed undercooling and freezing temperatures of 10 to 60 insects for each species at each refrigeration temperature. Extent of variation of observations at each temperature is indicated by short lines showing the standard deviation of the samples. Wide diversity of both undercooling and freezing points is apparent with descending refrigerator temperatures. Duration of exposure in the refrigerator for undercooling decreased as the refrigeration temperature was lowered for all types of holders. The time of undercooling for a particular species at a given refrigerator temperature was correspondingly greater for individuals with lower observed undercooling points. The undercooling temperature and subsequent freezing was fatal to all species except larvae of the cold-hardy hibernating European corn borer.

In active squash bug and Mexican bean beetle adults there was a slight lowering of the observed undercooling points as starvation progressed. This is probably a direct result of the lowering of body water (Ditman *et al.* 1942).

Discussion of Undercooling Results.—Variations in trends of observed undercooling points with descending refrigeration temperatures are caused by variations in heat conductivity, in specific heat and in density of the materials used in construction of the various types of

[1] Scientific Paper No. A44, Contribution No. 1871 of the Maryland Agricultural Experiment St tion, Department of Entomology.

[2] Eastern Branch Program, New York, November, 1942.

[3] Now Chief Engineering Aide U. S. Public Health Service. Formerly Assistant, University of Maryland, Department of Entomology.

[4] Measures of lethal low temperatures for species of this group will be presented in a later paper.

[5] All temperatures in this paper on centigrade scale.

holders and in the location of the thermocouple. In the glass holder of Robinson the raising of the observed undercooling points as refrigerator temperature is lowered is caused primarily by thermocouple placement. Not only is the junction placed in the center of the apparatus above the insect, where it is farthest away from the source of cold, but is further protected by the insulating glass tube enclosing the highly heat conductive lead wires; consequently at low refrigeration temperatures the insect cools more rapidly than the thermocouple itself. The low conductivity of the combination cork-and-wool holder greatly retards the loss of heat from the enclosed insect so that at low refrigerator temperatures there is comparatively greater differential between the temperature of the cooling medium just outside the holder and that of the insect. This condition together with the fact that thermocouple leads are good heat conductors and are openly exposed to the refrigerator temperature within a short distance of the junction, appears to be responsible for the lowering of the observed undercooling point as the temperature of the refrigerator is lowered. Because of the greater heat conductivity of the rubber holder, which in part results from the intimate contact with the insect and a reduction of air spaces, there is but little effect of reduced refrigeration temperature on the observed undercooling points. A longer time is required to cool the rubber holder at a given temperature because the greater density of rubber involves more calories of heat, a fact which may also contribute to the reduced effect of descending refrigeration on the observed undercooling point.

The differences in the extent of the rebound and the observed freezing points in the different holders are caused primarily by differences in the heat conductivity of the materials of which they are made. It is greatest in the cork-and-wool holder, where the junction is well insulated; lowest in the rubber holder where the heat of fusion of ice is quickly absorbed.

Figures 2 and 3 show that nearly uniform observations of undercooling points are obtained at high refrigeration temperatures where the differential between the refrigerator temperature and the insect temperature is not great. The authors suggest that a holder of high heat conductivity be used in order to minimize the cooling of the specimen and thereby reduce the time of determination and also increase accuracy since long exposure of an insect in a holder may alter its normal undercooling temperature.[1] The rate of cooling can be controlled by keeping the temperature of the thermocouple against the insect within a degree of the temperature of the refrigerating solution.

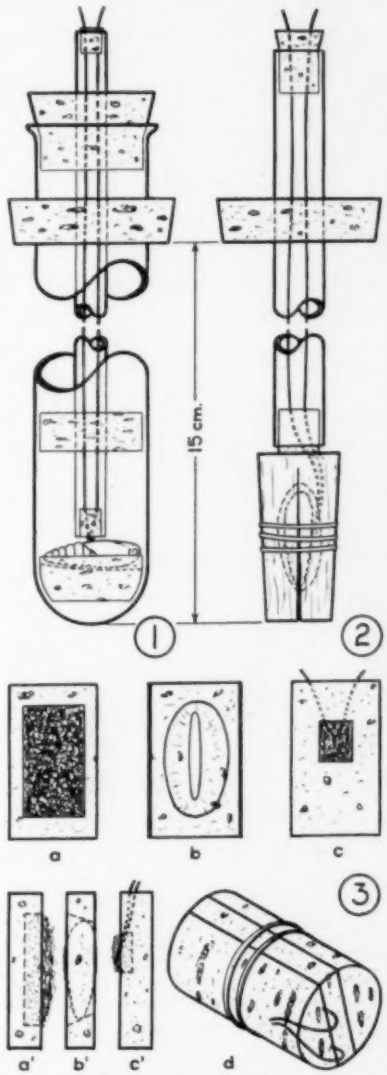

FIG. 1.—Various types of insect holders used in these studies for determining undercooling and freezing points. 1. Glass type holder as described by Robinson 1928. 2. Rubber holder as described by Salt 1936. 3. Cork and wool holder as described by Ditman *et al.* 1940.

[1] The effect of the duration of low temperature on stability of the undercooling capacity of insects will be treated in a later paper.

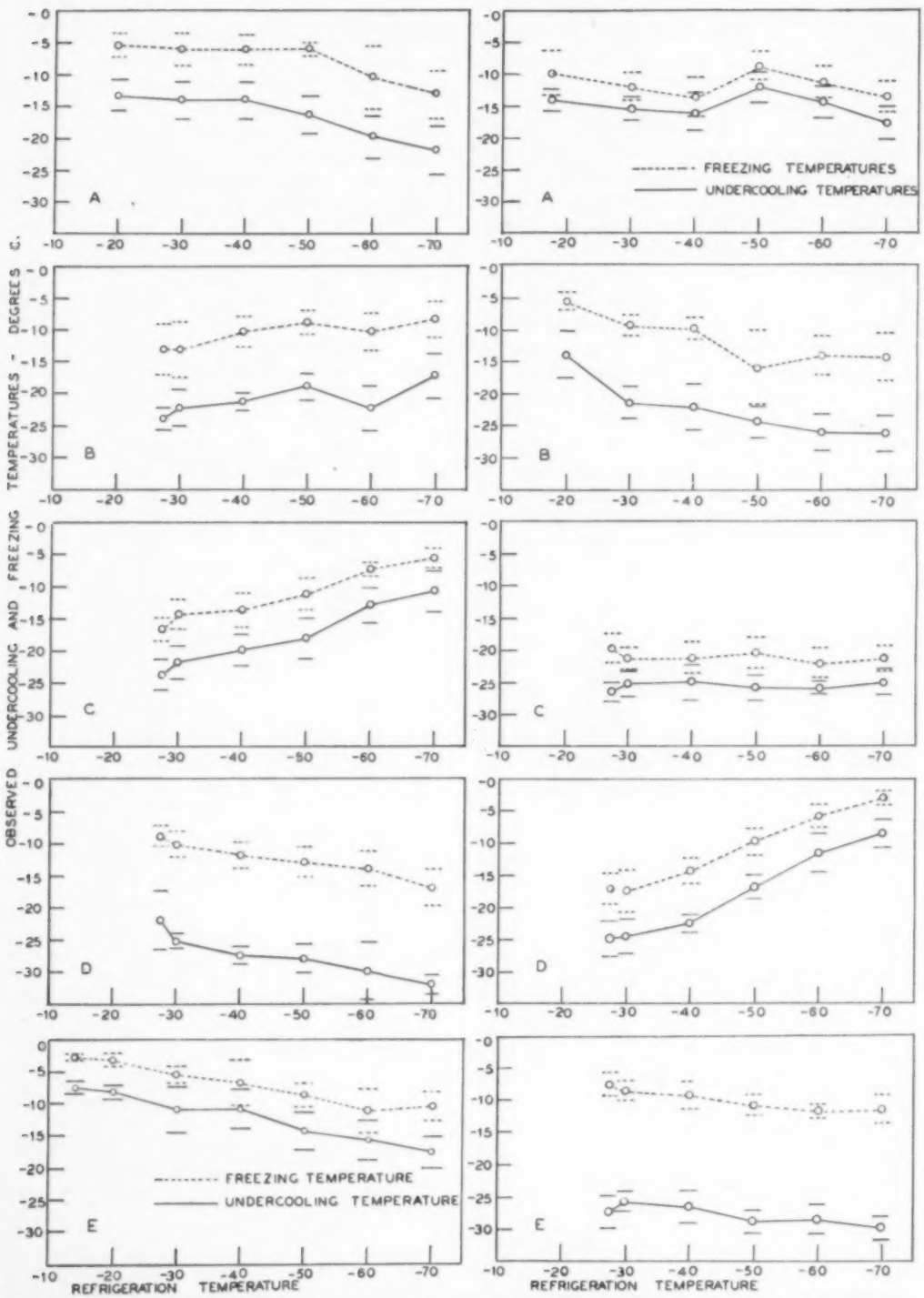

FIG. 2.—Effect of refrigeration temperatures on observed undercooling and freezing points. I, A to D, European corn borer larvae; A, active larvae in cork holder; B, hibernating larvae in rubber holder; C, hibernating larvae, glass holder; D, hibernating larvae, cork holder; I, E, Hibernating greater corn stalk borer larvae in cork holder. II. Codling moth larvae: A, active larvae, rubber holder; B, active larvae, cork holder; C, hibernating larvae, rubber holder; D, hibernating larvae, glass holder; E, hibernating larvae, cork holder.

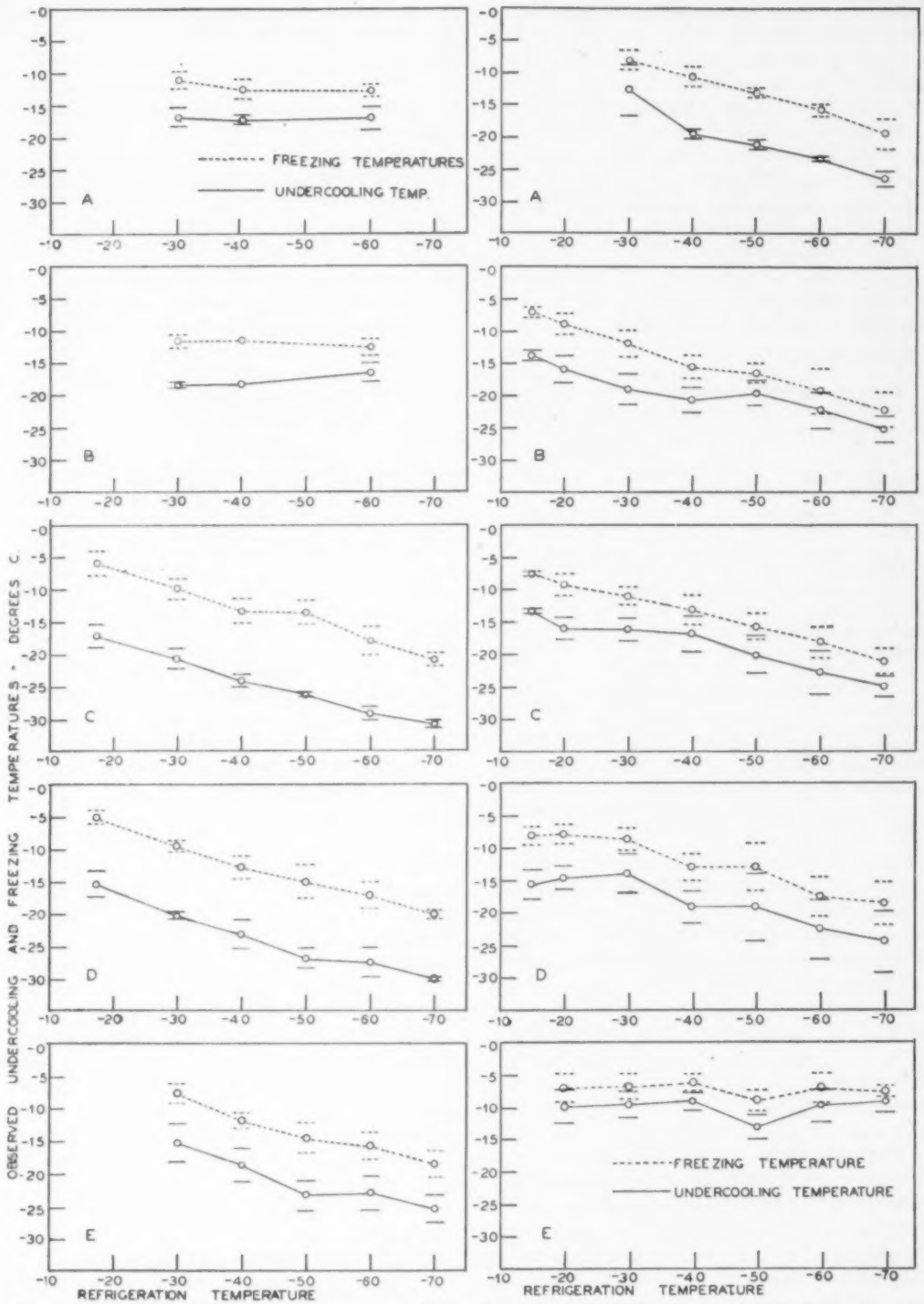

FIG. 3.—Effect of refrigeration temperatures on observed undercooling and freezing points. I. Corn earworm pupae: A, active male pupae, rubber holder; B, active female pupae, rubber holder; C, active male pupae, cork holder; D, active female pupae, cork holder; E, hibernating male pupae, cork holder. II. A, hibernating female corn earworm pupae, cork holder; B, active male adult squash bugs, cork holder; C, active female squash bugs, cork holder; D, active adult Mexican bean beetles, reared in laboratory at 24.5 degrees, 4 days old without food, humidity of rearing chamber 90 to 100 per cent, cork holder; E, active Mexican bean beetle adults, collected in field, run immediately in rubber holder.

With respect to the undercooling phenomenon, a living insect behaves in the same manner as water in a finely divided state. Water particles in a finely divided state in the absence of ice crystals or other solid particles that may act as nuclei for crystallization, in the absence of shock or movement may be undercooled to a considerable degree, comparable to the extent in many overwintering insects. Because undercooling of water is itself physical in nature and is influenced by physical or mechanical stimuli, it is logical to assume that undercooling as it occurs in insects is entirely a physical phenomenon brought about primarily by the distribution or condition of water in the insect organism. Materials in the colloidal state, which are present in large amounts in intra and extra-cellular fluids of an insect no doubt play a part in the distribution or condition of body water that in turn makes possible undercooling.

Table 1.—Relation of water content to undercooling range of the insects observed.

Species	Per Cent of Water	Undercooling Temperatures[1]
Hibernating		Degrees C.
Pyrausta nubilalis larvae	56–57	−21 to −25
Carpocapsa pomenella larvae	59–60	−25 to −27
Anasa tristis adults	57–61	−17 to −23
Diatraea crambidoides larvae	58–64	−6 to −9
Heliothis armigera pupae	64–68	−13 to −17
Active		
Anasa tristis	63–68	−12 to −15
Heliothis armigera pupae	66–69	−13 to −17
Pyrausta nubilalis larvae	67–69	−11 to −15
Epilachna varivestis adults	66–69	−8 to −12

[1] Data taken from Figures 2 to 6; averages of samples fell within these limits.

In the species and stages of insects studied there was a pronounced relation between the extent of cold resistance and low water content (Table 1).

DETERMINATION OF FREEZING POINTS.—It is evident from an examination of the results in figures 2 and 3 that observed freezing points are not true freezing points of the species concerned. Even when rebound temperatures remain stationary for one to three minutes, they are not true freezing points because the position of the thermocouple junction between the insect and the apparatus causes a recording of an equilibrium temperature between the insect and the holder when the rebound occurs. Values obtained through use of the cork-and-wool holder more nearly approach the true freezing point because of the better insulated junction.

It is evident, therefore, that true freezing points cannot be obtained by the usual methods for determining undercooling temperatures. In order to obtain freezing points, undercooling must be greatly reduced or eliminated. Salt, by his seeding technique and by melting-point determinations, obtained values closely approaching the true freezing points.

The freezing points of insects should be governed by the amounts of soluble salts or other materials in their body fluids and not by undercooling ability. It is a general characteristic of materials that form the colloidal state in water that they have a marked effect on undercooling of the resultant lyophil; on the other hand, such materials have in comparison with soluble salts very little effect on the actual freezing point of the solution. As a result of this reasoning, attempts were made to determine the freezing points of the species concerned by puncturing the insect with the thermocouple junction and freezing it in a cork holder at just low enough refrigeration to reach the greatly raised undercooling point.

The freezing point values obtained and corrected, as suggested by Salt, are presented in table 2 with the reduced undercooling points as obtained in this manner. Least variations in observed freezing points occurred in the largest insect, the active corn earworm pupa, where eight out of ten insects had an uncorrected freezing point of exactly −1 degree. This figure is in all probability the most accurate, as true freezing points for a stage and species should vary little as compared with undercooling points.

Freezing points obtained in this manner are in the range that would be expected from the chemical constitution of body fluids and are in line with the values secured by Salt by different technique. It is probable that true freezing points of insects are never more than a degree or so below zero. Many of the low values reported in literature are in all probability the result of technical misconception.

Freezing point values are of little eco-

nomic importance. They are of no use in determining lethal low temperatures, the undercooling temperatures being the most important criterion for most insects. They have been used by the authors only in the calculation of unfreezable water in insects (Ditman *et al.* 1942).

VALUE OF UNDERCOOLING TEMPERATURE.—Determination of undercooling temperature provides a comparatively quick and simple method of measuring the cold resistance of insects which do not survive maximum freezing of the body. If these determinations are properly made, they provide accurate information on cold resistance of insects as it occurs in the field under natural conditions. This information is of great assistance in interpreting the effect of low temperatures on a given insect species and is of value in predicting success of hibernation from season to season.

One should exercise great care in interpreting field conditions in terms of laboratory results. For some insects that hibernate in exposed places, where temperatures of hibernating quarters closely parallel that of the atmosphere, results obtained in the manner of the observations reported in this paper may be applied more or less directly to field conditions. Codling moth larvae hibernating on portions of a tree above the snow line should be nearly all killed by temperatures of −27 degrees. With information on the percentage of larvae that hibernate above snow coverage, we would be able to calculate that a certain percenatge of mortality has taken place at an atmospheric temperature of −27 degrees. The relation of descending temperatures to mortality can be graphically represented, as has been done for the codling moth larvae, figure 4. These data obtained in the laboratory no doubt closely approximate field conditions, provided that atmospheric temperatures persist for sufficient time. Protecting bark and cocoons would reduce the rate of cooling of the insects, but would not influence their undercooling temperatures.

Results obtained on dry earworm pupae would not accurately apply directly to field conditions. In the field during the winter months, hibernating pupae are subjected to more or less soil moisture, sometimes being even partially submerged. Under these conditions they would freeze at higher temperatures than those under dry laboratory conditions, where hibernating earworm pupae had undercooling points usually between −14 to −17 degrees. Barber & Dicke (1939) found this to be true; that dry pupae survived a temperature of −9.4 degrees, while exposure at this temperature in moist surroundings resulted in considerable mortality. They attributed this to the insulating effect of dry soil, to a dry pupal exoskeleton, and to a lower water content of pupae. However, the inoculation or seeding effect of external ice crystals is the probable explanation of heavy mortality for moist pupae. The seasonal variation of earworm population is greatly influenced by winter soil temperature, which in southern and eastern Maryland seldom if ever reaches as low as that required to kill pupae under dry laboratory conditions.

Ditman & Weiland reported observed undercooling points for corn earworm pupae in the region of −40 degrees. Such

Table 2.—Freezing points as determined by puncturing the insects with the thermocouple. Observed values corrected as suggested by Salt, 1936. Results based on 10 insects of each group.

INSECT	UNDERCOOLING TEMPERATURE			FREEZING TEMPERATURE			
	Low	High	Average	Low	High	Average	Corrected
Hibernating							
Carpocapsa pomonella larvae	9.8	6.9	8.9	2.7	1.8	2.1	1.8
Pyrausta nubilalis larvae	11.6	8.7	10.4	4.4	2.9	3.6	3.1
Diatraea crambidoides larvae	8.7	5.2	6.4	1.9	1.2	1.4	1.3
Heliothis armigera pupae	6.2	2.8	4.2	1.2	0.9	1.0	0.9
Active							
Anasa tristis adults (female)	9.5	6.1	7.5	1.4	0.9	1.2	1.1
Anasa tristis adults (male)	11.7	6.0	8.9	2.2	1.0	1.5	1.3
Pyrausta nubilalis larvae	6.2	4.8	6.8	1.4	0.9	1.4	1.3

observations have not been confirmed, and are no doubt in error. There is no difference between the undercooling temperatures of overwintering and active pupae. Likewise, there is little difference in water content of active and dormant pupae.

In estimating seasonal carry-over of corn earworm, one is concerned with a complex of factors, moisture, soil fertility, type of soil, alternate freezing and thawing, snow cover, weather conditions during the period when insects are going into hibernation, and winter atmospheric temperatures. Some of these have been discussed by Barber & Dicke (1939). Over a large area, many of these factors remain

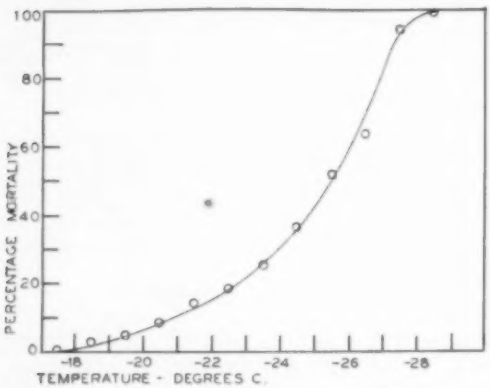

FIG. 4.—Lethal low temperatures for hibernating codling moth larvae, based on undercooling temperatures.

constant from season to season so that winter temperatures are the greatest variable and apparently the most important single factor in determining the seasonal variation in abundance of this insect.

It is evident that for some species of ininsects information regarding undercooling temperatures is of more direct value in determining winter survival than for other species. It should be reemphasized that methods and technique are of greatest importance in securing accurate information. Great consideration and care should be exercised in handling material for determinations, in making determinations, and in interpreting results. For example, in determining undercooling points of the squash bug, *Anasa tristis*, it was found that hibernating specimens left in the laboratory at 25 to 30 degrees overnight had undercooling points at −7 to −8 degrees; while freshly collected material had undercooling points of −15 to −24 degrees. Incidentally, this bug was collected under bark of old stumps, and was nearly always located in places that were dry; seldom was a specimen taken where the inner bark was moist.

In determining undercooling points for pupae of *Diatraea* it was found that if mechanical pressure was applied to the insect in the holder so as to flatten it slightly, its undercooling temperature was raised considerably. This reaction was not observed in the larval stage.

SUMMARY.—A comparison of types of apparatus for determining undercooling and freezing points of insects as described by Robinson and Salt, and by Seigler as modified by Ditman & Weiland, was made under refrigeration temperatures ranging from −8 to −70 degrees. At a minimum low temperature, all types of apparatus gave fairly accurate results, but as refrigeration temperatures were reduced, the three types of holders behaved differently because of differences in heat conductivity, specific heat, and density, and because of the location of the thermocouple with regard to source of refrigeration. With the type of holder described by Robinson observed undercooling points were higher as refrigeration temperatures were lowered; with the cork-and-wool holder of Ditman & Weiland observed undercooling points varied directly with refrigeration temperatures; with the rubber holder of Salt observed undercooling points were not greatly influenced by refrigerator temperatures. The extent of the rebound is also influenced by different types of holders; it was greatest with the cork-and-wool holder and least with the rubber holder. Accurate observed undercooling and freezing points cannot be determined in the same operation by the use of present methods.

Undercooling appears to be a physical condition brought about by the reduction and distribution of water in the insect in which it is suggested that materials colloidal in nature play a part. Both undercooling and freezing points are influenced by reduction of body water.

Information on the extent of undercooling is useful in interpreting and predicting winter survival of insects in the field, but must be applied with great care. For ex-

ample, it is pointed out that laboratory observations on undercooling points of overwintering codling moth larvae closely approximate conditions in the field; while those for corn earworm pupae under dry laboratory conditions indicate a greater resistance to cold than actually occurs in the field in moist soil.—2-8-43.

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The Status of the Mosquitoes of the Great Swamp in Rhode Island During 1942[1]

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There are no previous publications on the biology of the Rhode Island mosquitoes, and relatively few studies have been devoted to swamp species in New England. The Great Swamp covers 10 square miles, and lies midway between Newport and Westerly, 6 miles west of the mouth of Narragansett Bay and 4 miles from the south shore of the Atlantic. Salt and brackish marshes extend to within 2 miles and several military establishments and installations are located within a 10-mile radius. Because of the similarity of the numerous fresh water swamps in this small state, the account given for the Great Swamp probably applies generally to the fresh water swamp fauna of the entire state.

Most of the principal habitats are illustrated in figure 2. Most of the swamp is densely wooded, and numerous trees were uprooted by the hurricane of 1938, leaving a corresponding number of holes often associated with root holes. Tree holes, however, are not common. The Chipuxet River is a typical stream. Since all streams are sluggish and choked with vegetation, there are many isolated bordering pools. Bordering the Chipuxet is a broad flood plain with numerous shallow and deep pools characterized by shrubs and a dense mat of grasses and sedges. This plain is seldom flooded. Pitcher plants abound in certain areas along its edges. Beyond the flood plain cranberry bogs and leatherleaf bogs are common. Most of the swamp area consists of pools and depressions. Very shallow grassy pools are numerous, but deeper pools which contain sphagnum moss and leaves are in the majority. Root holes are usually associated with them. The water level is highest in early spring, gradually subsides to a low ebb in late summer or early fall, and toward mid-fall the level again rises. With the fall in level the acidity of this very acid swamp increases and the water color darkens. This lowering of level accounts for the temporary or permanent nature of the various breeding places. Furthermore, even in permanent pools it is responsible for the creation or abolition or suitable breeding places for the various species with their varying seasonal histories, because practically all larvae and pupae of swamp species are found in matted vegetation rather than in open water. During the spring of 1942, at high level, marginal grasses extended into

[1] Eastern Branch Program. New York, November, 1942.

the water and thus afforded protection for early spring *Aedes*. During late May and early June, the water level dropped below the marginal grass level. The bare banks thus exposed afforded little protection, and no larvae or pupae were found. At a still lower water level, from late June to early October, previously submerged grasses and sedges appeared which afforded protection for the multiple-generation species of mosquitoes. When the level rose again in October, a condition similar to that of late May or early June pre-

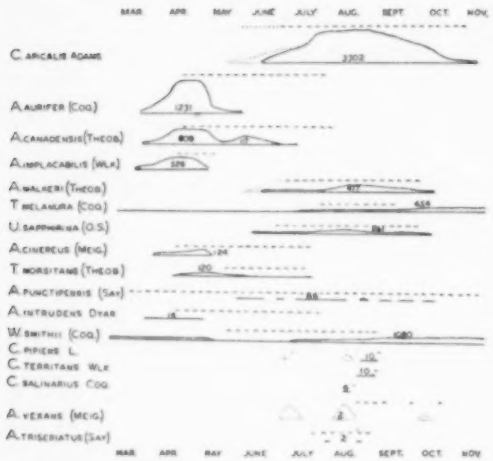

FIG. 1.—Seasonal distribution of larval and adult collections in the swamp proper. Larval collections are indicated by a continuous line which is curved to show seasonal abundance. The actual number of larvae collected is given for each species, which indicates a ratio of abundance except with *Wyeomyia smithii* (Coq.). Dashed horizontal lines include emergence, biting, and other collection records of adults. Dotted lines show cases when the seasonal history outside was known to differ from that in the Great Swamp.

vailed; with this came a sudden drop in populations. Relatively little precipitation during April and May undoubtedly hastened the drop in level to a small extent, although a series of heavy rains later in the year did not greatly affect it in the swamp. While swamp conditions during 1942 were nearly typical, deviations from these are to be expected in certain years when precipitation is not close to normal.

No larvae were taken in Worden's and Larkin's Ponds, located in the swamp, apparently because of surface wavelets arising from the absence of proper amounts and kinds of vegetation.

Bordering the swamp are temporary and permanent pools and streams somewhat intermediate between upland and swamp types.

Highways and railroads have greatly increased the growth of marginal grasses, and contribute to increased mosquito populations.

Wright (1941) reported on the ecological type plants of the Great Swamp. Getting & Feemster (1940) reported on a Massachusetts survey conducted from June to November during 1939. This extensive study was more qualitative than quantitative in nature.

METHODS OF INVESTIGATION.—Weekly randomized samplings at typical stations were made from February to December, 1942, and populations were measured by a pint dipper (Fig. 2). Many larvae were determined immediately, while others were reared for pupation and emergence data. Adult collections were made during larval samplings and on other occasions. Dr. Alan Stone aided in the work by the determination of a few of the more difficult atypical specimens. Light trap operations were seriously handicapped by dimout regulations.

THE CHIPUXET RIVER AND FLOOD PLAIN MARSH.—The banks consist mainly of overhanging marginal grasses and segregated bordering pools with dense growths of water lilies, sedges, etc. (Fig. 2). In early spring, when the water level is highest, larvae of early spring *Aedes*, especially *A. aurifer* (Coq.), *A. canadensis* (Theob.), and *A. implacabilis* (Wlk.) were taken sparingly under marginal grasses. By mid-June larvae of *Anopheles walkeri* (Theob.) and *Culex apicalis* Adams were taken at the rate of one to the dip. Both reached a peak of three to the dip during August, declined throughout September, and had almost disappeared by mid-October. *Uranotaenia sapphirina* (O. S.) occurred sparingly during late August. In early spring as the ice was melting, the bordering deeper pools of the river also possessed marginal grasses, and abounded with *Aedes aurifer* at the rate of five to the dip, and *A. canadensis* and *A. implacabilis* at two to the dip. *A. intrudens* Dyar was rare. In the temporary grass-matted river pools, *A. cinereus* (Meig.) averaged eight to the dip, *A. canadensis* three to the dip, and *A. aurifer* one to the dip. By mid-May these pools had dried up. *Theobaldia morsitans* (Theob.) and *A.*

FIG. 2.—Habitats of the Great Swamp. No. 7 was taken in early April at high water level, while the remainder show low water level conditions during late summer. 1. Uprooted tree pool partially invaded by vegetation; few mosquitoes breed here. 2. Chipuxet River with bordering river pools and flood plain marsh; arrow indicates habitat of *Anopheles walkeri* (Theob.). 3. Stream showing one of few places where *A. punctipennis* (Say) was found. 4. Permanent river pools; arrow shows overhanging grasses which no longer serve as larval protection because water level has dropped. 5. Permanent cranberry bog which, in early spring, is covered with water back to the trees; now previously submerged vegetation serves for larval protection. 6. Temporary sphagnum moss pool which has become dry except for the permanent root hole; although the most numerous of the habitat types, relatively few mosquitoes are bred. 7. Temporary early spring grassy pool, one of the most prolific producers of *Aedes*. 8. Permanent sphagnum moss pool which produces few mosquitoes.

canadensis favored seepage and spring-fed pools of clearer water. During summer and early fall *Anopheles walkeri* averaged one larva to four dips, while *C. apicalis* was taken five to the dip. Taken rarely with these were *T. melanura* (Coq.) and *U. sapphirina* from late July until November. The water level was lowest during early October. *Anopheles punctipennis* (Say) occurred sparingly and locally along the stream edges, especially as they entered the swamp.

The temporary pools of the flood plain marsh are matted with grasses, and had mostly disappeared by mid-April. *Aedes implacabilis* was taken four to the dip, but other species were rare. The larger permanent pool fauna resembles that of the deeper pools bordering the river, with *A. aurifer* taken eight to the dip. *Theobaldia morsitans* was taken sparingly. By mid-May the water level had lowered below the grass line, after which only a few *Culex apicalis* and *Anopheles walkeri* were taken from late June to mid-October in what little protective vegetation remained. *T. melanura* was found sparingly in early October. These pools started to refill during early October.

SWAMP POOLS AND BOGS.—Temporary swamp pools include (1) shallow grassy depressions (Fig. 2), (2) shallow sphagnum moss pools and associated root holes (Fig. 2), and (3) smaller cranberry bogs. The first type affords ideal breeding places for *Aedes implacabilis* and *A. cinereus*, which were taken five to the dip. *A. canadensis* was taken two to the dip, while *A. intrudens* was rare. Most of this first type dried up in April. The second type, the temporary sphagnum pool, often contains many leaves but has much less vegetation around the edges. The fauna was similar to that of the temporary grassy pool, but the species occurred at the rate of only one-fifth larva per dip, and *Theobaldia morsitans* was taken rarely during late May. Many dried up in May, while the root holes remained filled longer to produce a late brood of *A. canadensis* during late May and early June. The third type, the temporary cranberry bog, produced *A. canadensis* and *A. aurifer* 10 to the dip, while *A. implacabilis* occurred one to the dip, and *A. intrudens* was rare. The majority dried up in late April or May.

Permanent swamp pools include (1) deeper sphagnum pools (Fig. 2) and associated root holes, (2) cranberry bogs, and (3) leatherleaf bogs. In the first type the early spring habitat and fauna were similar to those of the temporary type. *Culex apicalis* was taken sparingly throughout the summer when little vegetation occurred at low water level. Most root holes contained water throughout the year and provided continuous breeding for *Theobaldia melanura*. This species became more abundant as the season progressed and was more prevalent in the denser portion of the swamp. *Aedes canadensis* was taken at nearly one to the dip in the more open and grassy root holes during late May and early June, which was a later date than in the other habitats. Root holes, because of their lower level, are first to refill in the fall. Permanent cranberry bogs (Fig. 2), the second type, are usually bordered with an abundance of vegetation early in the spring. This is ideal for *A. canadensis* and *A. aurifer* which were taken ten to the dip. *A. implacabilis* and *A. intrudens* were rare. *T. morsitans* was taken rarely in May. In mid-April the water level dropped below the grass level and consequently there was no protection for larvae or pupae. It was not until mid-June that the water level subsided so that previously submerged vegetation was exposed (Fig. 2). Then *Culex apicalis* was taken ten to the dip and *Uranotaenia sapphirina* two to the dip, and each increased to a peak during late July and August. They gradually dwindled in numbers and disappeared in mid-October when the bog started to refill rapidly. Two larvae of *C. salinarius* Coq. and one of *A. vexans* (Meig.) were taken in mid-August. Permanent leatherleaf bogs, a third type, produced the typical early spring *Aedes* and *T. morsitans* in the mat at high water level. They occurred in small numbers, however, apparently because of the scarcity of marginal grasses. When the level had dropped by mid-June, *C. apicalis* appeared about three to the dip, and remained until mid-November. Peculiar to this bog were a few *C. pipiens* L. and *C. territans* Wlk. during late August and early September. *T. melanura* and *C. salinarius* were taken rarely in mid-August.

HOLES PRODUCED BY UPROOTED TREES.—These resemble the typical permanent sphagnum moss holes, both as to habitat and fauna. However, because of relatively

recent hurricane action, some are not yet well invaded by moss and leaves. Both types favored *Aedes implacabilis*, which was taken at the rate of one-tenth larva per dip. The permanent type was invaded by *Culex apicalis* at the rate of one larva per five dips, from mid-June until early October. These two species were twice as common in the more open areas where more marginal vegetation was afforded.

PITCHER PLANTS.—Colonies are common along the border of the river flood plain. Larvae stay well to the bottom of the water in the leaves and seldom come up for air.

TREE HOLES.—Suitable holes for breeding are rare. *Aedes triseriatus* (Say) was taken twice in August.

POOLS AND STREAMS BORDERING THE SWAMP.—*Aedes excrucians* and *A. fitchii* (F.&Y.), although not taken in the swamp proper, were the most prevalent early spring species in these pools. The former was taken four to the dip in the shallower pools, while the latter was slightly predominant in the deeper pools at the rate of slightly more than one to the dip. *Anopheles punctipennis* (Say), *Theobaldia morsitans*, and *Culex apicalis* were occasionally found in late May and early June at lower water level, because protective marginal vegetation always occurred. The latter species did not appear in the swamp proper until nearly mid-June, when vegetative protection was first afforded. Heavy August rains filled larger holes sufficiently so that single generations of *Anopheles punctipennis*, *C. apicalis*, and *Aedes vexans* were able to develop, the latter at the rate of 20 to the dip.

One stream during late summer and early fall abounded with *Anopheles punctipennis*, *Aedes vexans*, and *Culex pipiens* along its grassy edges. While it is apparently a normal habitat for *A. punctipennis*, *A. vexans* was washed down from cow tracks in a pasture above, and *C. pipiens* similarly originated in a sewage disposal plant.

GENERAL CONSIDERATION OF SPECIES BREEDING IN THE GREAT SWAMP.—The species, beginning with the most common, are discussed below in relation to their relative abundance as larvae, taking into consideration the relative areas of each habitat and the number of generations undergone in a season. Graphic representations of both larval collections and adult collections and rearings are given in figure 1.

Culex apicalis Adams. This multiple generation species appeared by mid-May in pools bordering the swamp, and emerged as early as May 29, as indicated by the dotted line in figure 1. It was widely distributed throughout the swamp proper, but larvae and pupae were not common there until the third week in June, and first adults emerged June 25. Larval populations reached a peak during late July and August, gradually subsided through September and October, and terminated in mid-November. Last emergence dates were on November 12. It is not known to feed upon man.

Aedes aurifer (Coq.). Second and third instar larvae of this one generation species were taken March 27 in pools of melting ice, but a considerable number of first and second instars were not found until the second week in April. Pupae first appeared during the third week in April, and most had pupated by May 12. Adults emerged from April 21 to July, but mostly in late April and early May. Larvae were most abundant during the last three weeks of April and early May. It bred primarily in river pools, flood plain pools, and in cranberry bogs. It was both the most common and the fiercest biter, especially in mid-afternoon in the shade. Although a pest until the end of July, it was most noticeable in May and June close to the breeding places. Most workers have experienced difficulty in locating the larvae, although, many have found adults plentiful.

Aedes canadensis (Theob.). This species was widely distributed, and its seasonal history coincided closely with that of *A. aurifer* at all stations except root holes. In the latter, larvae did not appear commonly until the last week in May and early June. They had mostly disappeared by the third week in June. Consequent to this was a late emergence during early June. Since the root holes remained frozen for a longer period, it appears that low temperatures retarded development and that these individuals represent the same generation. Hence this species seems to have undergone but one generation in the swamp. Although it did not bite as aggressively as *A. aurifer*, it ranked second as a pest, and was especially irritating in May and June during the afternoon.

Aedes implacabilis (Wlk.). This one gen-

eration species developed nearly a week earlier than *A. aurifer*. Fourth instar larvae were present on March 29, pupae by April 12, and adults on April 15. Most larvae were taken in April, and were especially abundant in temporary leafy pools. Maximum emergence occurred from mid-April to May 6. Adults attacked shyly throughout the day, but it ranked only fifth as a pest.

Anopheles walkeri (Theob.). This multiple generation species first became common during mid-June. It reached maximum numbers during late August, fell off through September, and had nearly disappeared by mid-October. First and second instar larvae were always predominant, probably indicating a high larval mortality. Maximum emergence occurred between July 1 and September 3. It was abundant under overhanging marginal grasses of the Chipuxet, and to a lesser extent in the bordering and flood plain pools. Adults attacked commonly during late August and early September, especially near the breeding places on cool evenings, but to a lesser extent throughout the day. They attacked silently and bit immediately upon alighting, usually about the knees or ankles. It ranked tenth as a pest.

Theobaldia melanura (Coq.). Overwintering larvae were active soon after the ice had melted, but became more numerous in mid-July. The peak was attained during early October and remained thus until hibernation at mid-November. Although taken sparingly in permanent leatherleaf bogs and river pools, it was much more common in root holes. Emergence was recorded from July 26 to September 12.

Uranotaenia sapphirina (O. S.). The general seasonal history resembles that of *Aedes walkeri*, although it was in advance about one week. It favored the permanent cranberry bogs. Greatest emergence occurred between June 26 and September 1.

Aedes cinereus (Meig.). This species occurred slightly later than the other early spring *Aedes*. Although larvae were taken from March 29 to May 10, the peak was attained on May 3. It was especially common in temporary grassy pools. It ranked eighth as a pest, but attacked fiercely throughout the day during May, June, and early July.

Theobaldia morsitans (Theob.). Fourth instar larvae were taken from mid-April until late July, with many small larvae present by early May. They were most abundant throughout May, and occurred in those seepage pools, spring-fed pools and root holes in which a fairly constant water level was maintained. Maximum emergence occurred during late May and early June.

Anopheles punctipennis (Say). Overwintering females were common at lights as early as late April, and were taken rarely in cellars throughout the winter. Larvae were found from late May to mid-October but only intermittently and locally in small numbers under overhanging grasses of streams. The peak was attained during late August. Although it was the predominant species of the genus in the uplands, *A. walkeri* was much more common in the swamp. One biting record on man was secured during mid-August at 5 P.M. in a college building.

Aedes intrudens Dyar. The few larvae found were taken from March 29 to May 3. A typical early spring *Aedes* seasonal history is therefore indicated. Pupae were recorded from April 20 to 30. It ranked fourth in numbers as a pest, however, indicating that many must have come in from the uplands. It bit mostly in late May and June, but was collected until late July.

Wyeomia smithii (Coq.). Overwintering larvae of the second, third, and fourth instars were common, with the third slightly predominant. Pupae were first found commonly on May 24, and first emergence was on that date. On June 27 females were commonly ovipositing in new leaves. Adults emerged as late as September 6, but there was no pupation after that date. Larvae became slightly more abundant about mid-July, continued to increase until late August and September, and then remained constant on through the year.

Culex pipiens L. Ten larvae were taken in a leatherleaf bog in late August and early September following heavy rains. The adults reared from these could not be induced to bite man. They were also taken, along with *Aedes vexans*, in pools bordering the swamp during early July and in mid-August. It was rarely a pest in the swamp, although quarries in the uplands produced enormous numbers.

Culex territans Wlk. Ten third and fourth instar larvae were taken in a leatherleaf bog on September 2. It bred more commonly in partly sunken row

boats on the ponds in late August.

Culex salinarius Coq. Four larvae were taken with *C. apicalis* during mid-August in cranberry and leatherleaf bogs. It was rare in the nearby uplands.

Aedes vexans (Meig.). Two larvae were taken during the second week in August in a permanent cranberry bog. Following two series of heavy rains, one during early July and another in mid-August, two generations were noted in pools bordering the swamp. Larvae appeared in an upland pool in early October. This species fed diurnally, mostly in late August and early September, and ranked eleventh as a pest.

Aedes triseriatus (Say). Samplings on August 1 and 24 netted but two larvae from the few tree holes found. It was most annoying in late July and August, and often entered houses. It ranked thirteenth as a pest.

OTHER PEST SPECIES IN THE GREAT SWAMP AREA.—*Aedes excrucians* (Wlk.). This one-generation species invaded the swamp proper from bordering pools. It ranked third as a pest, biting during the afternoon from mid-May until late July. It was taken commonly in the light trap and in houses.

Aedes sollicitans (Wlk.). This multiple generation salt marsh breeder had entered in small numbers by late May, gradually increased to a peak in August and September, and then rapidly disappeared. It ranked sixth as a pest.

Aedes cantator (Coq.). This multiple generation salt and brackish marsh breeder accompanied *A. sollicitans* (Wlk.) in slightly smaller numbers. It was more prevalent in September, and ranked seventh as a pest.

Mansonia perturbans (Wlk.). This one generation species was a fierce biter during late June and July in the evening, and some entered houses. Although its habit of moving long distances is well known, this species probably breeds to some extent in the swamp, because plants suitable for larval and pupal attachment are apparently common there.

Aedes fitchii (F.&Y.). This one generation early spring species bred in moderate numbers in the deeper pools bordering the swamp. It moved into the swamp proper and bit in June and July in the afternoon. It ranked twelfth as a pest.

Aedes stimulans (Wlk.). Although no larvae or pupae of this one generation species were found, as a pest it ranked fourteenth and bit fiercely during late June and July.

Psorophora ciliata (Fab.). Females were taken twice while biting on the neck in in bright daylight at 3 P.M. during late August and on September 9.

OTHER SPECIES TAKEN NEAR THE GREAT SWAMP AREA.—*Aedes trivittatus* (Coq.), *A. trichurus* (Dyar), *A. atropalpus* (Coq.), and *Orthopodomyia signifera* (Coq.) were also taken during 1942.

COMMON CHABORINAE OF THE GREAT SWAMP.—*Corethra fuliginosa* Felt was common in root holes, and *C. cinctipes* Coq. was found in temporary pools bordering the swamp in May.

MOSQUITOES OF THE SWAMP AREA AS RELATED TO HUMAN DISEASE.—*Anopheles walkeri*, often considered rare in the literature, is a potential vector of malaria. It bred in abundance along the Chipuxet and to some extent along borders of several upland pools in the vicinity. It fed on man commonly during late August and early September. *A. walkeri* must therefore be considered a potential threat for the spread of malaria in Rhode Island, when infected individuals are exposed to their bites. Many war workers and service men from endemic areas to the south have come to this vicinity.

Anopheles punctipennis (Say), although the most common species of the genus in the uplands of southern Rhode Island, not only was rare in the swamp proper, but also was not very abundant in pools and streams bordering the swamp. While a proved vector of malaria, it is not generally considered a very effective natural vector. Only one specimen was found feeding on man.

Anopheles quadrimaculatus (Say), the most important vector of malaria in this country, was taken by Dean John Barlow in nearby cellars while overwintering as adult females. No larvae were taken in the swamp. Mr. E. L. Coman, however, during early September took several larvae at Narragansett Pier, only four miles away. These were taken along grassy edges of a permanent fresh water pond.

Only two species known to transmit experimentally equine encephalomyelitis bred in the swamp, and both were rare in the swamp proper. These were *Aedes triseriatus* and *A. vexans*. The latter, however, bred profusely in pools bordering the

swamp. *A. sollicitans* and *A. cantator* entered from salt and brackish marshes two or more miles away. *A. atropalpus* (Coq.) was taken in rock pools at Narragansett. Although some search was made for *A. taeniorhynchus* (Wied.) in nearby salt and brackish marshes, none was found. It is evident that this species was at least not common in the vicinity.

PROBLEMS OF ABATEMENT IN THE GREAT SWAMP AREA.—Early spring *Aedes* of the swamp proper were severe pests during late spring and early summer at a large Girl Scout camp and at several summer cabins and beaches at Larkin's and Worden's Ponds. They apparently moved upland in numbers for at least one half mile. *A. aurifer* and *A. canadensis* were the most important in and about military installations. They could be materially reduced by one chemical treatment of the grassy edges of cranberry bogs and small temporary and permanent grassy pools along highways, railroads, the Chipuxet, and other of the open areas, as it is in these that they breed most profusely. Treatment should be conducted in late March or April. The much more numerous but less important sphagnum and uprooted tree pools toward the interior do not produce sufficient individuals to justify treatment. Under the present faunal conditions drainage or filling of the pools of this relatively flat swamp with its many and widely scattered shallow temporary pools is not practical. Permanent root holes did not breed sufficient economic individuals to justify abatement efforts.

The pools bordering the swamp, although they too breed the principal early spring *Aedes* of the swamp as well as *A. excrucians* and *A. fitchii* not found in the swamp proper, offer an easier opportunity for abatement measures because they are fewer in number and more readily accessible. Chemical treatment appears more promising than draining or filling because of the great depth of the majority of the pools. Subsequent treatments after a series of heavy rains would destroy huge numbers of *Aedes vexans* (Meig.) and smaller numbers of *Anopheles punctipennis* (Say).

Since *Aedes sollicitans* and *A. cantator* are salt marsh breeders, abatement measures would necessarily be conducted at their source.

Although *Anopheles walkeri* was abundant, the fact that it was confined to overhanging grasses of the Chipuxet and the immediate portion of the flood plain narrows the point of attack. The removal or chemical treatment of the overhanging grasses, possibly accompanied by bank straightening, is practical. Furthermore, any operation which lowers the water level below the overhanging grass level would be effective. The proper management of dams constructed at various river points, or at Thirty Acre Pond or Hundred Acre Pond which feed the Chipuxet, would accomplish this. It is doubtful if dredging alone would greatly affect the level, because the variation in elevation is very slight throughout the swamp. The fish fauna, with possible predators in view, has not been studied.

Abatement measures against *Mansonia perturbans* do not appear practical at present population levels. This problem is further complicated since actual breeding places have not been established in the swamp and the submerged existence of larvae and pupae make treatment more difficult.

Although *Culex pipiens* L. is an important pest near the swamp and about military establishments and installations, it is a very minor breeder in the swamp and its control lies in the proper treatment of receptacles and quarries.

Aedes triseriatus (Say) probably breeds primarily in artificial receptacles, because adults apparently far exceeded in number the potential productivity of the few tree holes in the swamp.

SUMMARY.—The Great Swamp, a typical Rhode Island fresh water swamp, is located in the southern portion near several military installations. The swamp consists of fourteen general larval habitats, and eighteen species of Culicinae bred in it. Six additional species came in from nearby, and four others were collected in the area. Larval and adult weekly collections from February to December are graphically represented in figure 1, and the species are discussed in relation to their habitats and relative prevalence.

Several early spring *Aedes* larvae, especially *A. aurifer*, *A. canadensis*, *A. implacabilis*, and *A. cinereus*, were very common, and the first two became severe pests. Although each preferred its own habitat, all developed mainly along mar-

ginal grassy edges when water level was highest, and underwent one generation. During late May and early June, when the level dropped in most habitats so that the grassy protection was gone, almost no larvae were taken. During this interval larvae were common only in those habitats in which the water level remained nearly constant. These included *Wyeomyia smithii* in pitcher plants, *Aedes canadensis* and *Theobaldia melanura* in root holes, and *T. morsitans* in seepage areas. By late June the level had lowered further, and previously submerged vegetative protection appeared. Here *Anopheles walkeri* and *Culex apicalis* (multiple generation species) were predominant, the former along the Chipuxet and the latter almost everywhere. *Uranotaenia sapphirina* occurred with these in smaller numbers. These species continued to breed throughout most of October, but then suddenly disappeared when a rise in water level produced conditions similar to those of late May and early June. Hence, the seasonal histories in the swamp coincided with the available vegetative protection as determined by water level.

Theobaldia morsitans occurred sparingly in many permanent pools. Three species of *Culex*, *C. pipiens*, *C. salinarius*, and *C. territans*, were rare.

Pools bordering the swamp bred *Aedes excrucians* and *A. fitchii*, not found in the swamp proper.

Of the potential malaria carriers, *Anopheles walkeri* was decidedly predominant in the swamp, while *A. punctipennis* was more common along the swamp border and in the uplands. *A. quadrimaculatus* was taken close by.

Of the known experimental vectors of equine encephalomyelitis, *Aedes triseriatus* and *A. vexans* bred rarely in the swamp, but the latter underwent two enormous broods in bordering pools following two series of heavy rains. *A. sollicitans* and *A. cantator* came in from nearby salt marshes, and *A. atropalpus* was collected nearby.

The sphagnum pools, which make up much of the dense flat swamp, afforded little protection for larvae and produced relatively few species of economic importance. However, there are many shallow grassy pools in open areas bordering roads and streams, and these along with cranberry bogs produce hoards of early spring *Aedes* pest mosquitoes. Chemical treatment of the grassy edges during late March or April is practical; drainage or filling is not. Should abatement of *Anopheles walkeri* become necessary, one of the following procedures is recommended: (1) chemical treatment of the grassy edges (2) removal of overhanging grasses, possibly accompanied by bank straightening, and (3) any operation which lowers the water level below the overhanging grass level, such as the construction and proper management of dams. Dredging would be of doubtful value.

Pools bordering the swamp are fewer in number and more temporary in nature. Chemical treatment is, in general, preferred to drainage or filling.—1-10-43.

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MEXICAN FRUITFLY QUARANTINE

Because of the increased number of Mexican fruitfly infestations in the regulated area of the lower Rio Grande Valley of Texas, the Chief of the Bureau of Entomology and Plant Quarantine issued administrative instructions (Circular B.E.P.Q. 528, dated May 6, 1943) requiring the sterilization of grapefruit shipped from the regulated area during the remainder of the 1943 spring shipping season.

Pyrethrum Culture in Dalmatia with Some Applications to the Americas

ALBERT HARTZELL, *Boyce Thompson Institute for Plant Research, Inc., Yonkers, New York*

As there is renewed interest in the growing of pyrethrum in the United States (Culbertson 1940; Sievers *et al.* 1941) due to the supply being cut off by World War II, observations on the plant in its native home may be of interest. I shall therefore attempt to describe briefly the whole process of pyrethrum culture from seed harvest, sowing, transplanting, harvesting, bailing and milling, based on my own observations made several years ago in Dalmatia and the available literature (Slaus-Kantschieder 1913; Juillet *et al.* 1924; Hartzell 1933; Gnadinger 1936). The bailing and milling processes will be mentioned only incidentally, while the chemical and toxicological phases of pyrethrum have been omitted intentionally as falling outside the scope of this paper.

Pyrethrum (*Chrysanthemum cinerariaefolium* Vis.) is found growing wild in the Dinaric Alps which skirt the eastern coast of the Adriatic Sea, and in the islands off the Dalmatian coast where it was first observed and reported in 1694. As with many drug plants, the natives were aware of the properties of pyrethrum long before the scientists. Nevertheless it is only since 1847 that we can point with certainty to *Chrysanthemum cinerariaefolium* as an insecticidal plant (Juillet *et al.* 1924). The discovery of its insecticidal properties is usually attributed to a lady in Ragusa (Dubronik) by the name of Anna Rosauer who picked a bouquet of pyrethrum flowers for decorating an apartment. When they withered she threw the bouquet in a corner where several weeks later they were observed surrounded by dead insects. Associating the death of the insects with properties possessed by the plant, she began milling pyrethrum into powder. At her death the manufacture of the powder was continued by a local pharmacist (McDonnell *et al.* 1920).

Prior to World War I, practically all pyrethrum that was produced for export came from Dalmatia and was shipped principally from the port of Trieste (Slaus-Kantschieder 1913). Shipments in 1913 reached more than 5000 tons. The first world war put an end to this supply enabling Japan to seize the market which she retained until shipping shortage in the Pacific cut off supplies about a year before the United States entered the present war. The original seed for the extensive plantings in Wakayama Prefecture, Japan, was obtained around 1885 from Dalmatia (Gnadinger 1936).

CULTIVATION.—While a considerable portion of pyrethrum (Fig. 1)[1] is obtained from wild plants in the mountains or from old sheep pastures, abandoned fields, and vineyards, some is raised simply by broadcasting the seed directly on plowed fields. Pyrethrum does not establish itself readily however, so that if a good stand is desired it is usually necessary to start it in a seed bed and transplant to the field.

Seed.—The best seed is collected from wild plants in the mountains. The flower heads are threshed from the dried flower clusters by means of a flail. Seeds soon lose their vitality and are said to be practically non-viable after 2 or 3 years, although seed stored in a sealed container has been known to be viable after 5 years. About 50 per cent germination is expected under ordinary storage conditions. The low germination rate is due partly to lack of embryos. The seeds are stored preferably in metal containers.

Sowing.—The seeds are sown at the end of March and are covered with fine soil to a depth of a half-inch.[2] They are then covered with a leaf mulch. Germination requires 2 or 3 weeks after which the leaf mulch is removed. Seed beds of light fertile soil with southern exposure are usually selected. Time may be saved by sowing in September and transplanting the following March. It requires a seed bed of about 50×50 ft. to furnish enough seedlings to plant an acre. When pyrethrum is grown without transplanting simply by broadcasting the seed directly on the plowed field, the rate of seeding is about 10 or 11 pounds per acre.

[1] Figures 1 to 4 from photographs furnished through the courtesy of Mr. Stephan Ćećuk, Split (Spalato), Yugoslavia. Figures 1 and 3, half-tones furnished through the courtesy of MacNair-Dorland Company, New York, N. Y. Figure 2 (lower), published with permission of C. B. Gnadinger, Minneapolis, Minn.

[2] For convenience, metric units have been converted to their approximate English equivalents.

FIG. 1.—Pyrethrum field in bloom.

Planting.—Fields with southern exposure are preferred. The soil is trench-plowed to a depth of about 6 inches and manured. The soil types are limestone loams and dolomite clays. The land is stony and well drained.

Transplanting from the seed bed to the field is done the fore part of March preferably after a heavy rain. At this time the plants are a year old, about 4 inches tall, and have 7 or 8 leaves. Plants may also be obtained from cuttings from stalks or by division of crowns. The plants are spaced in the field 12 to 16 inches in all directions or are planted in rows 18 inches apart and 20 to 30 inches in the row. It requires approximately 45,000 sets to plant an acre. Pyrethrum plants grow slowly and spend the first season in establishing a root system. The following year the crowns spread rapidly and fill in the intervening spaces in the rows. Shallow cultivation, which consists principally of weeding and hoeing, is the rule. The plants are 20 to 24 inches high at maturity.

The first crop is light; the maximum yield is obtained the third blooming season. Plantings generally must be renewed after 4 or 5 years. Individual plants are said to have lived for 20 years.

The growers at Trogir (Trau) informed me that the favorite rotation was pyrethrum 2 or 3 years, maize 1 year, wheat 1 year, and beans 1 year.

HARVESTING.—The harvest usually begins the fore part of May when the flowers are about three-fourths open. The plants are cut with a sickle at the base a few inches from the ground and are bound in bundles (Fig. 2, upper). The heads are detached from the stalks by means of a comb (Fig. 2, lower). In some localities the flowers are picked in large sacks by hand by the women and children and are sorted as to degree of openness into *open*, *half-open*, and *closed* flowers. This practice it appears has been largely discontinued as closed flowers no longer command a premium. As the picking of the flowers causes the hands to become sore, a maximum of from 30 to 60 pounds is about all that one person can gather in a day. The use of a binder or self-rake for harvesting the crop is said not to be feasible under Dalmation conditions as the fields are usually not more than 2 or 3 acres in extent and are very steep and rocky. Nor, so far as I could learn, are artificial methods of drying employed. The average yield of flowers per acre is low, about 150 to 300 pounds although yields of 700 pounds per acre are not uncommon.

The proportion of flowers to stems is about 1 to 3. The flowers are piled to a

thickness of from 1 to 2 inches on strips of cloth (Fig. 3, upper). They are stirred frequently with a rake to hasten the drying process and to prevent heating. The flowers usually are dried for one day in the sun and then are removed to the shade to finish drying which may require 4 to 5 days or more, depending on weather conditions. Drying completely in the shade is also practiced. The flowers lose about three-fourths of their weight in the process of drying. The moisture content of dried flowers is about 10 per cent.

PREPARATION OF PYRETHRUM FOR MARKET.—Transportation of the harvested flowers, particularly those from the mountainous districts of Dalmatia, presents a difficult problem because of the lack of suitable highways to the interior. Several days may be required to reach the mill or warehouse. On the way the flowers may have been heated and a product which may have been high in pyrethrin content when it left the farm may be practically worthless by the time it reaches the mill or warehouse.

Owing to the relatively high cost of milling abroad and the possibility of adulteration, practically all the pyrethrum formerly shipped to the United States from Dalmatia was dry flowers in the form of bales of 100 to 150 kilos (220

FIG. 2.—(Upper.) Harvesting pyrethrum with a sickle. (Lower.) 'Heading' pyrethrum flowers.

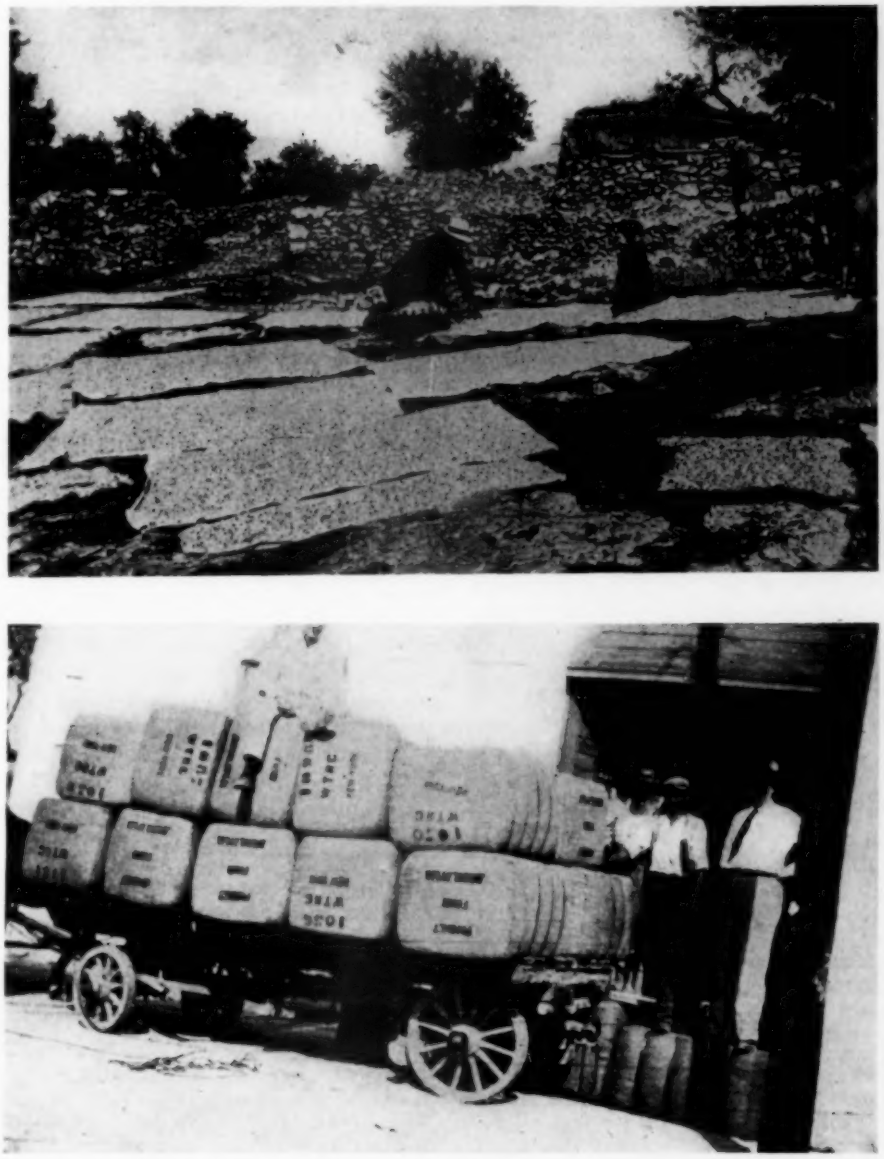

FIG. 3.—(Upper.) Drying pyrethrum flowers on strips of cloth.
(Lower.) Pyrethrum bales ready for shipment.

to 330 lbs.). In the warehouse that I visited at Split the dried flowers were compressed into bales of 310 lbs. (Fig. 3), and baled in hydraulic press (Fig. 4).

There are mills at Sebenik (Sebenico), Trogir, and in the adjacent islands. The Italian city of Trieste is also a large milling center for pyrethrum grown on the islands in the Gulf of Quarnero. In a mill I visited at Trogir the flowers were ground by a pair of vertical millstones about two and one-half feet in diameter rotating in a hopper. Power was furnished by a gasoline motor. The product of this mill was packed for the local trade. It was put up in small triangular cardboard boxes, each with an opening at the apex end, closed with a tack, which when withdrawn permitted a bellows effect for dusting. Ground pyrethrum should pass a 300-mesh sieve.

INSECTS AND DISEASES OF PYRETHRUM.—Certain species of aphids are known to attack the roots of pyrethrum. Three species of beetles have been reported by Kazanetski (1927) as pests of pyrethrum in Dalmatia. Stems of withered plants are often infested by *Phytoecia virgula*. The roots are injured by *Pentodon punctatus* and *Haplidia transversa*.

A disease caused by *Sclerotinia libertiana* is known to attack pyrethrum in Europe (Rivier 1922).

QUALITY OF DALMATIAN PYRETHRUM.—Both chemical and biological analyses show that different shipments of pyrethrum vary considerably in insecticidal performance. In general, the Dalmatian product has been inferior to pyrethrum produced in Japan (Hoyer & Leonard 1936). This had discouraged the establishment of warehouses in Dalmatia by American pyrethrum importers even before the supply was cut off by the present war. Through the initiation of the Yugoslav Office of Foreign Trade and in collaboration with American specialists, a Pyrethrum Institute was established in 1936 at Split, which aimed at working systematically for the production of pyrethrum and for increasing the percentage of the active ingredients. It was believed that proper methods in handling, such as avoiding excessive exposure to sunlight in the drying process, reduction in the percentage of stems, better methods of baling, and so forth, would improve the quality of the crop.

FIG. 4.—Hydraulic press for baling pyrethrum flowers.

Recently Beckley *et al.* (1938) has shown that the higher elevations (5000 to 8000 ft.) in Kenya Colony are more favorable for pyrethrum growing than the lower elevations, and as altitude increased there was an increase in the flowering until at an elevation of 8000 ft. practically all the plants bloomed and continued in flower the year around. Plots at 5800 ft. yielded 4 hundredweight of dried flowers per acre while at 6500 ft. the yield was 6 hundredweight per acre. This is believed to be due to the effect of daily alternations in temperature brought about by high day temperatures followed by relatively low night temperatures. It is well known that Kenya flowers have a high pyrethrin content. Beckley *et al.* report an average of 1.21 per cent total pyrethrins for open flowers.

It has been known for a long time that certain mountainous districts of Dalmatia and Montenegro produced pyrethrum of superior quality and received a higher market price (Slaus-Kantschieder 1913). The fact that it has been the custom to obtain seed from wild plants grown high up in the mountains is also supporting evidence that high elevation is favorable for a superior product. Pyrethrum has been reported flourishing at elevations of 6000 ft. (Slaus-Kantschieder 1913). Because of the restricted area of mountain land available for cultivation and difficulties of transporting the crop, large scale production in Dalmatia has been confined to the coastal strip at relatively low elevations. It is possible that after the present war a relocation of pyrethrum acreage to higher elevations may result in an improved Dalmatian product.

SOME APPLICATIONS TO THE AMERICAS.—One of the chief reasons why pyrethrum has not been grown commercially in the United States is the large amount of hand labor involved in growing and handling this crop. Countries like the United States with a relatively high wage scale for agricultural labor have not been able to compete with Japan and other low wage scale countries. Until recently machine methods of harvesting have not been available. Higbee (1942) has pointed out that as a result of a newly invented harvester (Sievers *et al.* 1941), pyrethrum will probably become an important crop in the Americas.

In attempting to grow pyrethrum in the Americas the importance of elevation

should not be overlooked. Areas in the Andean highlands in equatorial South America are similar climatically to the region in Kenya in which flowers of high pyrethrin content are grown. It is very likely that Peru and Equador, because of their large areas of high elevation, will become important pyrethrum production centers. To a limited extent certain plateau areas in western United States may also become centers of production of high quality pyrethrum. Extensive areas in eastern United States ranging from Pennsylvania southward are suitable climatically and agronomically for growing pyrethrum but owing to the peculiar requirement of the plant, as stated above, nearness to market and machine methods probably would have to offset superior quality pyrethrum grown at high elevations in tropical countries.

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AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS
COTTON STATES BRANCH

The Eighteenth Annual Meeting of the Cotton States Branch of the American Association of Economic Entomologists was scheduled for the City of New Orleans on February 10 and 11, 1943. A preliminary notice was sent to the membership in September 1942 and a formal notice in early December 1942. Following the cancellation of the annual meetings by the parent organization the secretary of the Cotton States Branch contacted the Office of Defense Transportation. This Federal agency requested that the New Orleans Meetings be postponed. The officers of the Cotton States Branch issued through its secretary a letter of official cancellation. This went forward to the membership on January 8, 1943.

There follows a Financial Statement for the Cotton States Branch.

FINANCIAL STATEMENT
COTTON STATES BRANCH

From February 3, 1942 to May 1, 1943
Funds Received 1942 and 1943

January 30, 1942, Amount on hand, in savings	$119.32
January 30, 1942, Amount in checking account, University of Florida	92.09
March 11, 1942, Received from Secretary Ernest N. Cory, American Association of Economic Entomologists	79.06
Dues Received 1942–1943	106.00
Contributions 1942–1943	10.00
May 1, 1943, Interest on deposit in First National Bank, Atlanta, Georgia from Jan. 1, 1942 to Jan. 1, 1943	1.18
Total amount received during year	$407.65
Funds Expended	
Miscellaneous items	$120.43
Balance on hand May 1, 1943	287.22
Total	$407.65

JOHN T. CREIGHTON
Secretary-Treasurer
Cotton States Branch

Gainesville, Florida
May 6, 1943

SCIENTIFIC NOTES

Shade Tree Insects and Protective Concealment in Military Areas[1]

E. P. Felt and S. W. Bromley, *Bartlett Tree Research Laboratories, Stamford, Conn.*

This paper aims to forecast in some measure the probable insect injuries to shelter trees retained or planted for protective concealment in and near the numerous recently established camps and other military areas in this country.

Defoliation Weakens Trees.—The elm leaf beetle, *Galerucella xanthomelaena* Schrank, is a well known, widely distributed, and serious pest of elms. It causes a general browning of the foliage in badly infested areas and weakens trees to such an extent that in a few years sickly and dying branches are common. Such wood affords most favorable breeding places for the European elm bark beetle and is an important aid in producing conditions favorable to the development of the Dutch elm disease.

Another insect, the Japanese beetle, *Popillia japonica* Newmn., is becoming increasingly abundant and injurious to trees in the New England states. It produces widespread browning and foliage injury on a considerable variety of trees. The grubs are most destructive to the sod of lawns and golf greens and may cause similar damage on military reservations.

Stripped Trees Attract Borers.—The connection between attractiveness to borers and extensive defoliation by such notorious leaf eaters as Cypsum moth caterpillar, *Porthetria dispar* Linn., cankerworms, especially the spring cankerworm, *Paleacrita vernata* Peck, and the fall cankerworm, *Alsophila pometaria* Harr., the forest tent caterpillar, *Malacosoma disstria* Hubn., and similar pests is not generally recognized although it is well known that the loss of foliage produces conditions favorable to invasion by borers. There are a number of records of widespread killing of oaks in particular following the stripping of the trees by one of the foregoing leaf pests, the insect causing this usually being the two-lined chestnut borer, *Agrilus bilineatus* Web. Oaks weakened by sudden changes in environment such as a lowered water table, trees injured in connection with building or road construction are also most attractive to this deadly two-lined chestnut borer. Attacks by this pest may be relatively light for a few years, gradually increase in intensity; and finally result in the death of trees.

The related bronze birch borer, *Agrilus anxius* Gory, breeds by preference in weak or sickly birches, trees which may have been defoliated by insects or weakened by moving or changes in the supply of ground water.

Storm Damage Favors Borer Attack.—The situation is especially hazardous along the eastern coast in the area swept by the hurricane of September 1938. There were literally millions of trees overthrown or badly broken. Many were cared for in one way or another although large numbers were left in a weakened condition and have produced or are producing dangerous borers. The situation was rendered more critical by an extensive ice storm in 1940 which broke thousands of additional limbs and although many were removed there was still ample material for the breeding of enormous numbers of bark beetles. This was evident in southern New Hampshire where weakened elms produced many native elm bark beetles, *Hylurgopinus rufipes* Eich., which in turn infested others and killed a number of valuable trees.

The European elm bark beetle, *Scolytus multistriatus* Marsh., is a well known carrier of the Dutch elm disease and it, like the native elm bark beetle, multiplied tremendously as a result of earlier storm damage. This species is of economic importance largely as a vector of the Dutch elm disease. It has become so numerous in southern New England that many elms have been seriously damaged if not killed by the work of this borer. Observations show a great increase in the number of diseased elms in southwestern New England and with a prospective abundance of these carrier beetles, it is a fair presumption there will be a much greater increase in the number of affected trees in 1943 unless most of those already dying or diseased are disposed of before another growing season. With no Federal or State funds available for this work in the older affected areas, it follows that control must be secured through smaller political units, cities and villages with such cooperation as may be obtained from property owners. Available data indicated that much of the spread of the disease is from relatively nearby trees, some five-hundred feet from affected trees and consequently a city or village disposing of all infested elm wood in the streets and parks still has many presumptive dispersion units in diseased trees on private properties. Some property owners may remove their sickly or dying trees although the probabilities are that a number would not do this at their own expense. The alternative is local compulsion, preferably avoidable and usually unsatisfactory, or the removal of such trees at public expense. The cost of removing sickly or dying elms might be largely offset by the use of the wood for fuel. This can be handled more satisfactorily by a general agency than if it is left to the initiative of each owner.

This situation means that protective concealment from elms on military areas in sections where the Dutch elm disease occurs is at best precarious unless there is systematic disposal of the diseased trees within a quarter of a mile or thereabout of the trees to be protected.

Storm-Damaged Evergreens are Susceptible to Borer Attack.—The hurricane of September 1938 wrecked many pines in areas where it was most destructive and produced conditions favorable to prolific breeding of pine bark beetles, mostly *Ips calligraphus* Germ. and *Ips pini* Say, the former working mostly in the thicker bark and the latter attacking the thinner bark near the middle of the trunk and usually the more rapid killer. Both of these are most likely to attack trees standing in the open, especially if they have been recently exposed to light and unusual drying conditions by the removal of others nearby. The borers also show a marked preference for old trees growing under lawn conditions, as, for example, in cemeteries.

The New England pines which were partially overthrown by the hurricane are still producing beetles in such numbers as to threaten nearby healthy trees and to constitute a real hazard to recently set and, therefore, presumably somewhat weakened pines in military areas. This danger can be averted only by treatment which will keep the trees in a

[1] Eastern Branch Program. New York, November, 1942.

vigorous condition in spite of the root mutilation or shock of moving or the incidental injuries in connection with construction and development.

Similar danger, though presumably to a lesser degree, applies to other evergreens which have been moved in to provide protective concealment. The spruce bark beetle, *Dendroctonus piceaperda* Hopk., is a well known destructive species in the Adirondacks and northern New England. The balsam bark beetles, *Pityokteines sparsus* Lec., kill many firs or balsam in that same area and even junipers may be attacked by another bark beetle, namely, *Phloeosinus dentatus* Say, if the trees have been weakened by moving. The pine bark beetle, *Dendroctonus frontalis* Zumm., is a serious threat to southern pines.

VALUABLE CAMOUFLAGE TREES MOST SUBJECT TO ATTACK.—It is unfortunate that in military areas trees important for protective concealment are the ones most likely to be affected adversely by construction or developmental work and are, therefore, the ones more likely to be killed by borers. The effects of stripping or defoliation are more likely to be serious on weakened trees and, therefore, spraying is advisable to protect the foliage of trees in strategic positions. It is obvious that dead trees are of little value for protective concealment. It follows that avoidance or prevention of generally unfortunate tree conditions in newly developed areas depends largely on a knowledge of tree limitations and what can be done with them in order to maintain vitality and protect against insect attack and borer invasion. Here is a place where an entomologist familiar with shade tree insects can render a valuable service to our war effort.—2-12-42.

Host Plants of the Banded Greenhouse Thrips

PAUL M. EIDE, *U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

In the course of several years many kinds of plants have been grown in the greenhouse at the Sumner, Wash., laboratory. In particular, a collection of various types of amaryllids has been maintained for experimental purposes.

The banded greenhouse thrips, *Hercinothrips femoralis* (Reut.), has been present in this greenhouse and has infested many plants, as no general control measures were attempted. From time to time the plants were examined and the presence or absence of this species of thrips was noted. The degree of infestation observed on the various plants is given in table 1.

Hercinothrips femoralis has never been noted on the following plants in the greenhouse at the Sumner laboratory:

Begonia sp.
Dianthus caryophyllus (carnation)
Ferraria sp.
Lilium amabile
Lilium multiflorum
Lilium longiflorum var. White Queen
Pelargonium hortorum (common geranium)
Pelargonium graveolens (rose geranium)
Persea americana (avocado)
Phascolus vulgaris (bean)
Rosa sp.
Rhododendron sp. (azalea)
Solanum nigrum
Vallota speciosa (Scarboro lily)
Viola tricolor var. *hortensis* (pansy)
Zinnia sp.

Table 1.—The degree of infestation of *Hercinothrips femoralis* on various greenhouse plants.

NAME OF PLANT	DEGREE OF INFESTATION
Family Amaryllidaceae:	
Alstroemeria sp.	heavy
Amaryllis (*Hippeastrum*) sp.	heavy
Cooperia sp.	moderate
Hymenocallis coscinae	moderate
Hymenocallis festalis	very heavy
Hymenocallis harrisiana	heavy
Hymenocallis sp. var. Sulphur Beauty	moderate
Hymenocallis sp.	heavy
Narcissus sp.	light
Nerine bowdeni	heavy
Pancratium maritimum	moderate
Polianthes tuberosa	heavy
Sprekelia formosissima	moderate
Zephyranthes carinata	heavy
Zephyranthes candida	light
Zephyranthes rosea	heavy
Other families:	
Agapanthus sp.	moderate
Allium cernuum	light
Antirrhinum sp. (snapdragon)	heavy
Beta vulgaris (beet)	heavy
Bletilla hyacinthina	moderate
Brassica petsai (Chinese cabbage)	light
Buddleja sp. (summer lilac)	heavy
Calceolaria sp.	moderate
Callistephus chinensis (China-aster)	moderate
Chrysanthemum sp.	heavy
Chenopodium sp.	light
Coleus sp.	light
Crocus sp.	light
Cucumis melo (muskmelon)	light
Cucumis sativus (cucumber)	light
Ficus elastica	very light
Freesia sp.	light
Fritillaria lanceolata	light
Gerbera jamesoni (Transvaal daisy)	moderate
Gladiolus sp.	moderate
Gypsophila sp.	light
Ilex sp. (holly)	light
Lathyrus odoratus (sweetpea)	moderate
Lilium longiflorum	light
Lycopersicon esculentum (tomato)	light
Lobelia sp.	moderate
Oxalis sp.	light
Philodendron sp.	light
Raphanus sativus (radish)	light
Sinningia speciosa (gloxinia)	light
Sonchus oleraceus (sowthistle)	light
Stellaria media (chickweed)	heavy
Tagetes sp. (marigold)	light
Zantedeschia sp. (yellow calla)	moderate
Zygocactus truncatus (Christmas cactus)	light

There are indications that plants of the family Amaryllidaceae are preferred hosts, although *Narcissus* sp. and *Zephyranthes candida* did not seem to be particularly favored, and *Hercinothrips femoralis* has never been found on a small collection of *Vallota speciosa* plants during the several years of observations. However, these thrips also infest numbers of other plant families, sometimes seriously.

Notes were also made on the numbers of males and

females found, as the occurrence of males of this species of thrips is rather rare. During 1938 collections were made every month and the proportion of males was determined. The results are shown in table 2.

Table 2.—Males and females of *Hercinothrips femoralis* collected at intervals in the greenhouse at Sumner, Wash., in 1938.

Date	Females (Number)	Males	
		Number	Per Cent
January	320	2	0.6
February	543	2	0.4
March	273	0	0.0
April	233	2	0.9
May	358	0	0.0
June	136	1	0.7
August	426	5	1.2
September	590	23	3.8
October 1	194	8	4.0
October 7	65	11	14.7
October 27	151	2	1.3
November	253	6	2.3
December	260	1	0.4

Less than 1 per cent of males was found up to August, then the numbers increased gradually until early in October, when a maximum of 14.5 per cent was reached. After that the number of males decreased rapidly—1-13-43.

A Comparison of Methods for the Fumigation of Empty Banana Refrigerator Cars with Liquid Hydrocyanic Acid

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In the fumigation of empty banana refrigerator cars to free them of live Japanese beetles, *Popillia japonica* Newm., in compliance with quarantine regulations, one of the approved methods (United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, 1939) involves the use of liquid hydrocyanic acid at a dosage of 6 ounces per car. This is to be introduced in 2 measured dosages of 3 ounces each into "two metal trays having an area of 2 square feet and equipped to be suspended about 24 inches below the hatch cover. The temperature must be at least 75° F. in the car during the treatment."

The pans and other equipment necessary in this procedure are somewhat cumbersome and have led to requests for possible revision of the method. During the 1939 and 1940 seasons the writer was assigned to the problem for this purpose. A total of 32 cars were fumigated in cooperation with the fumigation staff of the United Fruit Company in the New York City area. Fumigations involved, for comparison, the standard application of 3 ounces each into pans in opposite bunkers, 6 ounces splashed against one bunker end wall, 3 ounces each splashed against the end walls of opposite bunkers, and 8 ounces splashed either against a single wall or as a divided dosage against opposite end walls. The splash method was suggested by Mr. John Carr of United Fruit Company. The pan method failed to conform with quarantine regulations in that the pans employed allowed for an evaporating surface of approximately 50 square inches each instead of the specified 288 square inches each.

Beetles used were freshly collected and were placed in well ventilated cages at various standard locations within the cars, top and bottom and on the bunker half-stage icing platforms. Readings for mortality were made within 24 to 48 hours after treatment.

The results are summarized in table 1.

Both of the splash methods employing 6-ounce dosages are inferior to the pan method used. This is demonstrated by the range in percentage mortalities for the individual tests. For the 6 ounce dosage applied against one end wall the range is from 89.99 to 100.0 per cent and for the divided dosage from 96.41 to 100.0 per cent. For the pan method the range is from 99.55 to 99.83 per cent mortality.

With the 8-ounce dosage both splash methods appear to be effective and suitable for use in quarantine treating. The ratio of survivors to total beetles was about 1 to 2,500 for the 4 tests with the fumigant splashed against a single end wall; and 1 to 3,500 for the 5 tests with 4 ounces against opposite end walls. In commercial practice, where few beetles per car ever are found, it is extremely improbable that any beetle capable of starting a new infestation would survive and escape from a refrigerator car treated by either procedure.

Mortality with the pan method was almost complete despite the use of an evaporating surface of less than one-fifth that specified in quarantine regulations, and with two of the four tests at a car temperature of less than 75° F. These records while not obtained for the purpose, imply the dependability

Table 1.—Summary of experimental refrigerator car fumigations with liquid hydrocyanic acid. Exposure period 2 hours. 1939 and 1940.

Introduction Method	Number of Cars	Car Temperature Range °F.	Number of Beetles	Average Per Cent Mortality	Range in Mortality for Individual Tests
6 oz. splashed on 1 bunker end wall	12	73–80	34,840	97.63	89.99–100.0
3 oz. splashed on each bunker end wall	7	76–80	19,614	98.33	96.41–100.0
3 oz. in pan in each bunker	4	73–76	12,346	99.76	99.55–99.83
8 oz. splashed on 1 bunker end wall	4	75–80	10,062	99.96	99.91–100.0
4 oz. splashed on each bunker end wall	5	74–80	10,477	99.97	99.85–100.0
	32 tests		87,339		

of the standard quarantine treatment for empty banana refrigerator cars. Based on the improbability of escape of any beetles capable of starting a new infestation following treatment, they likewise indicate the reliability of a pan method employing two pans, each with a surface area of approximately 50 square inches.—1-12-43.

The Relationship between Cropping Practices and Injury by *Heliothis armigera* with Especial Reference to Lima Beans and Tomatoes[1,2]

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During the past decade a marked increase in vegetable production for canning and quick freezing has developed in two different areas in New Jersey. From the beginning of this rapid change in cropping practices to the present, an outstanding transformation in food habits or host preference has been observed in regards to *Heliothis armigera* (Hbn.). Lima bean blossoms, especially when large acreages are centered in a given area, seem to attract adult *H. armigera* in great numbers, while the population in other crops rapidly declines. The two areas referred to are: (1) southern New Jersey, comprising parts of Cumberland, Salem and Cape May Counties; and (2) central New Jersey, comprising parts of Mercer, Burlington and Monmouth Counties.

From about 1930 to 1935 *Heliothis armigera* was causing considerable trouble to the tomato canners in the state due to the heavy infestation in ripening tomatoes. It was not uncommon during this period to find from 1 per cent to 15 per cent of the fruit injured by this insect. With the advent of the "gasoline method" of detecting insect fragments in canned goods, even with the greatest of care in sorting out infested tomatoes in the factory, some tomato products were condemned as being contaminated with insects.

Each year the canhouse tomato fields were surveyed by the entomologists and field representatives of the canning companies for fruit infestations.

THE SOUTHERN NEW JERSEY AREA.—Previous to 1935 records show that the infestation was fairly evenly distributed over the entire canhouse acreage of tomatoes in the state. About 1935 the acreage of Henderson bush lima beans for canning and quick freezing began to increase very rapidly from a few hundred acres to over 15,000 acres in the southern New Jersey area. Soon after the lima bean acreage began to increase in Cumberland County it was noticed that the injury to tomatoes by *Heliothis armigera* in this same area began to decrease and at the same time a noticeable increase of adult population appeared in the lima bean fields. As the lima bean industry expanded and spread westward into Salem County and southward into Cape May County the same relationship between the infestation on tomatoes and lima beans existed in these new areas. Yet when one examined tomato fields a few miles away from large fields of lima beans the tomato fruitworm infestations were in evidence.

A tomato survey involving all phases of tomato production was conducted by the New Jersey Agricultural Experiment Station from 1938 to 1940 inclusive. From 80 to 135 tomato farms representing the various canhouse tomato producing areas in the state were covered in this survey, except for the year 1938 which covered only Cumberland County. With few exceptions, each field in the survey was examined at least four times during the season for insect infestations and crop injury. The survey in 1938, covering only Cumberland County, did not show a single field infestation of tomato fruitworm. Out of 135 farms surveyed in 1939 only 15 fields showed signs of injury by *Heliothis armigera* and all of these were in areas where lima beans were not grown commercially. In 1940 only two fields out of 134 showed injury and they both were outside of the lima bean area.

From all indications adult moths are attracted from great distances by large acreages of lima beans. Tomato fields for a distance of 5 miles from lima bean fields have not been found to be infested while tomatoes 10 to 15 miles away show evidence of the insect. Another point which strongly indicates the attractive power of lima beans is the fact that within five days or more after the first fields of lima beans begin to blossom large numbers of moths may be found in these fields. Since there are few other host crops in the vicinity the only explanation for the large moth population is migration.

The moth population in these lima bean fields is almost beyond comprehension. During late August 1939 the writer collected 239 adults of *Heliothis armigera* in 20 minutes by sweeping the bean vines with a standard 14-inch diameter insect net. Seldom can one walk into a field of lima beans, when in blossom, without seeing several moths flying about.

The adults of this particular species are considered to be nocturnal insects. In corn, celery, cotton and tomato plants the moths seek some secluded spot to spend the daylight hours and begin their flight at dusk and throughout the night. However, it is recorded in the literature that moths occasionally have been observed feeding during the day. In the lima bean fields the adults fly freely and feed on the blossoms during the day, even during mid-day in bright sunshine. For some reason more moths have been observed in flight on bright days than on cloudy days. This may be due to the nectar secretion in the lima bean blossoms.

An attempt has been made to correlate the earworm damage on corn in the lima bean area with that outside of this area. Little sweet corn is grown in the South Jersey area except a few hundred acres grown for quick freezing purposes near Bridgeton. The ear infestation of this sweet corn has been exceedingly low as compared to the infestations on the same variety and maturity period in the Hammonton section some 25 miles east. Observations on field corn have also revealed that much less damage results in the lima bean area than on corn outside this area. Since the comparisons are made some distance apart it cannot be said with assurance that the attraction of the lima beans is responsible entirely for this difference in infestation.

Other unusual infestations of *Heliothis armigera* have been observed in the southern New Jersey lima bean area. After lima bean harvest in late summer and early fall spinach and broccoli often follow on the same fields or other fields in the same area. Infestations of *H. armigera* are partly responsible for the discontinuance of broccoli production in this area. On broccoli these larvae react as though they are a different species as compared to infestations in

[1] Paper of the Journal Series, New Jersey Agricultural Experiment Station, Rutgers University, Department of Entomology.
[2] Eastern Branch Program, New York, November, 1942.

corn, tomatoes or celery. Here, they seem to prefer to feed on the leaves rather than become concealed in the broccoli buds. Some rather serious infestations have developed on spinach in the Bridgeton area while in the northern spinach sections of the state *H. armigera* is seldom noted on this crop.

THE CENTRAL NEW JERSEY AREA.—About 1938 a canning company began contracting for Henderson bush lima beans in parts of Burlington, Mercer and Monmouth Counties. Prior to this time the only lima beans grown in this area were few very small plantings for the fresh market, while now the acreage runs 1000 acres or more. A considerable acreage of sweet corn for the fresh market and canhouse tomatoes are grown in the same area. Observations and surveys have been made on tomato infestations of *Heliothis armigera* before and after the advent of the lima bean industry in this area. The trends in the insect infestations are almost identical to those reported for the southern counties. Tomato fruitworm infestations in canhouse tomatoes have not occurred in this area since lima beans entered the picture. In eastern Monmouth County on fresh market tomato plantings 25 per cent or more of the tomatoes have been damaged by *H. armigera* for the past three years. Even in the market garden sections of northern New Jersey the tomato fruitworm is a problem.

The injury to the lima bean crop by *Heliothis armigera* is often very acute, especially on the later maturing fields, provided control measures are not applied. In 1942 it was estimated that 50 per cent of the crop on late maturing fields was destroyed by this insect.

The conditions just mentioned are an example of what might be expected from some of our common native insects in a changing agriculture. With present trends in our agricultural program we can see the beginning of new entomological problems, but it is quite possible that as new problems arise some of the current problems will subside or even may become extinct in the evolutionary process.—12-2-42.

Styrene Dibromide as a Substitute for Pyrethrum in Oil for Corn Earworm Control

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Because some insecticides in common use have or may become unavailable because of war conditions, the discovery of substitutes assumes unusual importance and interest. Therefore it seems desirable to report on styrene dibromide (alpha-beta-dibromoethylbenzene), one of the most promising among many materials tested as possible substitutes for pyrethrum in mineral oil for use against earworms, *Heliothis armigera* (Hbn.), in sweet corn. This compound is a colorless crystalline chemical having a mild naphthalene-like odor. It is soluble in mineral oil at the concentrations studied but goes into solution slowly. It was patented by Schechter & Haller[1] but no further work has been reported on it as an insecticide.

In preliminary tests in New Jersey when the chemical was used at the rate of 1 gram per 100 cc. of white oil of 125 to 135 seconds Saybolt viscosity at 100° F., applications of 0.75 cc. per ear to series of 10 ears of two fields of Golden Cross Bantam sweet corn resulted in an average of 95.1 per cent of larvae dead at time of harvest, 95 per cent of ears without live larvae, and 75 per cent with uninjured kernels. The ears in the checks contained no dead larvae, all contained live larvae, and only 10 per cent had uninjured kernels.

Further tests were made in which styrene dibromide was used at the rate of 1 gram per 100 cc. of oil in comparison with oil containing 0.2 per cent of pyrethrins or 2 per cent of dichloroethyl ether by volume. Applications of 0.75 cc. per ear were made in four fields of late sweet corn in Burlington County,

[1] U. S. Patent 2189570, Feb. 6, 1940.

Table 1.—Protection afforded ears of 4 fields of late sweet corn by applications of 3/4 cc. of white oil of 125/135 viscosity containing 1 per cent of styrene dibromide compared with that of other insecticides. Twenty-five ears were treated with each material in each field. Burlington County, New Jersey, 1941.

Insecticide Used in Oil	Per Cent Used in Oil	Condition of Ears in the Following Fields at Time of Harvest				
		Field 1	Field 2	Field 3	Field 4	Average
		Percentage of Ears Without Live Larvae				
Styrene dibromide	1.0	76.0	90.0	68.0	76.0	77.7
Pyrethrins	0.2	68.0	88.0	84.0	78.0	80.0
Dichloroethyl ether	2.0	—	90.0	62.0	86.0	79.3
Checks—untreated ears		4.0	20.0	0.0	4.0	7.0
		Percentage of Ears with Uninjured Kernels				
Styrene dibromide	1.0	44.0	94.0	48.0	62.0	64.6
Pyrethrins	0.2	48.0	92.0	60.0	62.0	64.0
Dichloroethyl ether	2.0	—	94.0	44.0	62.0	66.7
Checks—untreated ears		0.0	60.0	4.0	8.0	16.0
		Percentage of the Larval Population Found to be Dead				
Styrene dibromide	1.0	87.0	91.3	79.7	80.9	84.4
Pyrethrins	0.2	85.9	89.2	88.9	82.6	86.4
Dichloroethyl ether	2.0	—	89.8	68.9	89.6	82.0
Checks—untreated ears		1.9	3.2	5.9	0.0	3.1
Date ears were treated		Sept. 8	Sept. 11	Sept. 13	Sept. 13	
Date of harvest		Sept. 15	Sept. 16	Sept. 20	Sept. 19	

Table 2.—Protection afforded to ears of three fields of Ioana sweet corn by applications of 0.75 cc. of white oil of 125/135 viscosity containing from 0.5 to 1.5 grams of styrene dibromide per 100 cc. compared with that of other insecticides. Twenty-five ears were treated with each material in each field. Hidalgo County, Texas, 1942.

Insecticide Used in Oil	Per Cent Used in Oil	Condition of Ears in the Following Fields at Time of Harvest			
		Field 1	Field 2	Field 3	Average
	Percentage of the Larval Population Found to be Dead				
Styrene dibromide	1.5	78.3	100.0	88.6	89.4
	1.25	94.4	83.8	81.1	84.3
	1	87.5	80.0	82.7	83.0
	0.75	88.9	86.5	88.1	87.6
	0.5	87.5	82.4	72.5	78.9
	all concentrations	86.9	86.1	82.7	84.6
Pyrethrins	0.2	92.7	87.5	94.1	91.4
Dichloroethyl ether	2.0	89.7	90.9	92.0	89.7
Ethylene dichloride	2.0	84.4	83.7	87.5	84.8
Checks—untreated ears		0.0	0.0	0.0	0.0
	Percentage of Ears Without Live Larvae				
Styrene dibromide	1.5	80.0	100.0	76.0	85.3
	1.25	60.0	80.0	96.0	78.7
	1	68.0	80.0	88.0	78.7
	0.75	84.0	79.2	92.0	86.5
	0.5	60.0	80.0	92.0	77.3
	all concentrations	70.4	84.7	88.8	81.3
Pyrethrins	0.2	64.0	80.8	92.0	78.7
Dichloroethyl ether	2.0	84.0	88.0	88.0	86.7
Ethylene dichloride	2.0	80.0	68.0	88.0	78.7
Checks—untreated ears		32.0[1]	32.0[1]	40.0[1]	34.7
Date ears were treated		April 28	April 30	May 8	
Date of harvest		May 5	May 9	May 15	

[1] All check ears were infested but larvae were removed from the stated percentages by redwing blackbirds.

New Jersey, about a week before roasting-ear harvest. The results are summarized in table 1. Whether judged by the percentage of larvae found dead within the ears by the percentage of ears found without live larvae, or the percentage with uninjured kernels at time of harvest, the average effectiveness of styrene dibromide in oil compared favorably with that of oil containing pyrethrins or dichloroethyl ether.

In further trials made in Hidalgo County, Texas, in 1942, styrene dibromide was used in white oil at concentrations ranging from 0.5 to 1.5 grams per 100 cc. of oil in comparison with oil containing 0.2 per cent of pyrethrins, 2 per cent of dichloroethyl ether, or 2 per cent of ethylene dichloride. Applications of 0.75 cc. were made to ears of three fields of Ioana sweet corn about a week before roasting-ear harvest. The results are given in table 2. Whether judged by the average percentage of larvae found to be dead or by the percentage of ears without live larvae at time of roasting-ear harvest, the protection afforded the ears by oil containing styrene dibromide again compared favorably with that afforded by oil containing the other insecticides mentioned. These results also indicated that a concentration of 0.75 gram of styrene dibromide per 100 cc. of oil gave as satisfactory results as greater concentrations.

When dissolved, styrene dibromide imparts no color to the oil, and the solution causes no injury to any part of corn ears. Persons eating ears treated with the solutions mentioned failed to detect residue upon the kernels or any objectionable flavor imparted to them by the treatment.

Since no information on the toxicity of this chemical to warm-blooded animals seemed to be available, tests were made to determine its effect on rabbits. They were selected for this purpose because they would eat readily the parts of corn ears that contained the entire dosage of the insecticide. Rabbits weighing approximately 3.5 pounds were chosen because individuals of this size were old enough to eat green corn ears without digestive disturbances, and they would normally increase in weight during the time of experimental feeding. Series of sweet corn ears of a long-husked, local variety were oiled on September 11 with 0.75 cc. of white oil containing 1 per cent of styrene dibromide. Treated ears were harvested daily between September 12 and 19, and on September 21. The tip third or half of the ears, including the husk, all the interior silk, and the tip of the cob, which contains the entire dosage of the insecticide, was used as food. Each rabbit was given from 1 to 4 ears daily, the total number of ears eaten being 21 in the case of one rabbit and 25 in the case

of another. Two check animals received similar parts of the same number of untreated ears. On each day of feeding the rabbits devoured all parts of the ears and consequently, consumed all the dosage of the insecticide that had been applied. The total amount of styrene dibromide devoured by the rabbit eating 21 ears, if none of the chemical evaporated from the ears, was 0.16 gram, and for the rabbit eating 25 ears, 0.19 gram. No evidence was obtained that the rabbits were affected in any way after eating the ears containing the insecticide. They were observed until December 31, being fed regular rabbit ration after the termination of the described exerimental feeding. The animals that ate ears treated with the insecticide gained in weight as regularly as the checks, the average weights in ounces on October 2, October 31, November 30, and December 30, being 68, 86, 100.5, and 112, respectively, as compared with average weights of 64, 88, 101.5, and 120 ounces, respectively, for the checks.

Toxicity tests in which small amounts of white oil containing from 0.5 to 1 gram of styrene dibromide per 100 cc. of oil were applied to 135 larvae of different instars by a small camel's hair brush showed that the solution was a contact insecticide and had little value as a fumigant. Treated larvae did not die so soon after treatment as did those treated similarly with oil containing 0.2 per cent of pyrethrins, and some of them lived for several days following treatment. They usually did not eat after the insecticide was applied to them, however, although fresh food that bore no trace of insecticide was given daily. Of 55 larvae of fourth and fifth instars to which oil containing 1 gram of styrene dibromide per 100 cc. was applied as a contact insecticide, 85.5 per cent died. Since mortality of larvae to which oil containing 0.5 or 0.75 gram of styrene dibromide per 100 cc. was applied was only 67.5 per cent for each concentration, it is probable that the higher mortality resulting from the greater concentration was due to the higher proportion of the chemical present.

SUMMARY.—The results of field tests showed that styrene dibromide (alpha-beta-dibromoethylbenzene) when used at the rate of 0.75 gram or more per 100 cc. of white oil afforded protection to sweet corn ears at a rate that compared favorably with that resulting from applications of oil containing 0.2 per cent of pyrethrins, 2 per cent of dichloroethyl ether, or 2 per cent of ethylene dichloride. The chemical is slowly soluble in oil, imparts no color to it, and the solution causes no injury or change in appearance of any part of treated ears. Persons eating treated ears failed to detect residue on the kernels. The results of feeding treated ears to rabbits showed that the chemical was harmless to them when eaten in small quantities. The results of toxicity tests on earworm larvae showed that oil-styrene dibromide was a contact insecticide but that larvae often lived for several days after treatment, although they usually did not eat during this time.—1-7-43.

Utah Bird Predators of the False Chinch Bug

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The false chinch bug, *Nysius ericae* (Schilling), is a small grayish insect belonging to the hemipterous family Lygaeidae. The nymphs are grayish with reddish-brown abdomens. In Utah this insect breeds in large numbers on plants covering roadsides, deserted farms and desert areas, often being abundant among Russian-thistle, atriplexes, mustards, and in grassy places. When hordes of false chinch bugs swarm from roadside weeds or uncultivated land onto farms and into gardens, they frequently damage sugar-beets, alfalfa, cabbage, clover, potatoes, turnips, radishes, grasses and many other garden and forage crops. A study of the food of native insectivorous birds (table 1) has shown this insect commonly to be recognizable among the stomach contents of many bird species; it was found less commonly to rarely in the stomachs of other species of birds.

Table 1.—The number of false chinch bugs, *Nysius ericae* (Schilling), present in the stomachs examined of each of the 46 species of birds found to contain this injurious species.

BIRD SPECIES[1]	*Nysius ericae*	BIRDS CONTAINING	STOMACHS EXAMINED
Desert sparrow hawk	6	1	242
Ring-necked pheasant	7	1	14
Killdeer	2	1	11
Rocky mt. sapsucker	1	1	2
Arkansas kingbird	4	3	100
Eastern kingbird	1	1	20
Say phoebe	12	4	22
Wright flycatcher	1	1	5
Desert horned lark	311	25	178
Violet-green swallow	43	6	14
Rough-winged swallow	19	5	9
Barn swallow	76	17	59
Cliff swallow	4	2	7
Longtailed chickadee	6	3	17
House wren	2	1	4
Rock wren	355	29	63
Western mockingbird	1	1	2
Catbird	5	1	2
Sage thrasher	172	17	110
Mountain bluebird	71	19	177
Ruby-crowned kinglet	4	2	7
American pipit	1586	32	103
White-rumped shrike	1	1	65
Rocky mt. orange-crowned warbler	57	7	10
Western yellow warbler	38	10	19
Audubon warbler	45	18	59
Townsend warbler	10	2	3
Pileolated warbler	20	7	16
Western meadowlark	41	11	170
Redwing blackbird	2	2	76
Brewer blackbird	12	7	139
Bullock oriole	14	3	12
Lazuli bunting	4	1	3
Green-tailed towhee	1	1	3
House finch	1	1	47
Savannah sparrow	9	2	13
Western lark sparrow	55	14	89
Sage sparrow	164	17	46
Shufeldt junco	169	6	41
Western tree sparrow	6	2	2
Western chipping sparrow	1089	98	283
White-crowned sparrow	7	2	17
Gambel sparrow	69	14	126
Song sparrow	11	4	11
Lincoln sparrow	2	1	2
Western vesper sparrow	81	16	105
Total	4597	420	2525

[1] Most of the above bird common-names are those used by F. M. Bailey in her book—"Birds of New Mexico," 1928.

This study is based upon an examination of stomachs from a large number of insectivorous birds collected throughout Utah during the nine years from 1934 through 1942. *Nysius ericae* specimens were recognized in stomachs of 46 species of birds and totaled 3565 adult and 1032 nymphal specimens. This is a total of 4597 and an average of approximately 10.9 *N. ericae* per stomach for the 420 stom-

achs which contained this species. While only 25 of the 178 desert horned larks collected contained 311 recognizable *N. ericae*, 355 *ericae* were present in 29 of the 63 rock wren stomachs, and 1586 *N. ericae* were recognized in 32 of the 103 American pipit stomachs taken, 986 adult and 291 nymphal false chinch bugs being present in 18 stomachs of pipits collected in northern Utah, October 5, 1942. 1089 *N. ericae* were found in 98 of the 283 stomachs of western chipping sparrows.

One or more stomachs of all 46 species of birds listed (Table 1) contained adult *Nysius ericae*. Stomachs of 13 species contained 1032 nymphal false chinch bugs including 101 recognizable nymphs in stomachs of desert horned larks, 2 in long-tailed chicadees, 75 in rock wrens, 7 in sage thrashers, 4 in mt. bluebirds, 388 in American pipits, 6 in Townsend warblers, 1 in a western lark sparrow, 117 in sage sparrows, 67 in Shufeldt juncos, 218 in western chipping sparrows, 29 in Gambel sparrows and 17 in the western vesper sparrow.—2-16-43.

Sagaritis provancheri (D.T.), an Important Parasite of the Tobacco Budworm

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The tobacco budworm adult, *Heliothis virescens* (F.), usually lays its eggs singly on the ventral surface of the upper tobacco leaves. Soon after hatching, the young larvae crawl up to the bud of the plant, and start feeding on the young leaves of the bud. If allowed to continue feeding on the unfolding leaves of the bud, the budworm causes considerable damage to the tobacco plant. In Virginia, the budworm first appears around June 1, and can be found during the remainder of the tobacco growing season.

Early in June a number of fields were heavily infested with first and second instar budworms. It was observed that the budworms were destroyed by a parasite *Sagaritis provancheri* (D.T.),[1] an ichneumonid fly.

LIFE HISTORY OBSERVATION.—*Sagaritis provancheri* (D.T.) usually kills the tobacco budworm in its second or third instar. Budworms, with well developed parasites, are easily recognized by their greyish white or yellowish green color. They do not feed and are usually found resting on the end of a leaf. When the parasite is ready to pupate, it leaves through a hole adjacent to the thorax on the ventral side of the budworm's abdomen. Only an empty exo-skeleton and head capsule is left of the budworm. In a short time, the parasite spins its cocoon. Most of the cocoons are found on the dorsal side, near the apex of a leaf near the bud. If the plant has developed seed pods, the pupae of the parasites will be found sticking to the sides of the seed pods. The pubescent hairs of the tobacco leaf, as well as the threads of the pupa, help to hold the pupa on the leaf. The average diameter of the pupae was 2.0 mm., while the length was 5.5 mm. Two larvae were collected as they emerged from their host. Cocoons were spun within a few hours; the adults emerged 5 days later.

A few hyperparasites, *Spilochalcis side* (Walk.),[2] were reared from the cocoons of *S. provancheri* (D.T.) collected at Chatham, Virginia.

[1] Thanks are due to Mr. R. A. Cushman for the identification.
[2] Thanks are due to Mr. A. B. Gahan for the identification.

Table 1.—The per cent of tobacco budworms parasitized by *Sagaritis provancheri* (D.T.) in Pittsylvania County, Virginia, during 1942.

FIELD NO.	DATE	TOTAL NUMBER OF BUDWORMS[1]	PER CENT OF PARASITIZED BUDWORMS
1	June 21, 22, 23	124	27.6
2	25	50	76.0
3	26	55	60.0
4	29	48	70.8
5	30	62	80.6
6	July 1	23	60.9
7	1	17	94.1
8	2	25	64.0
9	3	51	70.6
10	6	8	75.0
1	6	10	60.0
11	7	13	46.2
4	7	8	87.5
5	8	9	66.7
2	9	12	59.7

[1] A pupa of the parasite is considered as a parasitized budworm in making the survey.

SURVEYS.—To obtain information regarding the parasites, 15 half-acre sections were selected in eleven tobacco fields. These fields each contained 5 or more acres and were located in different parts of Pittsylvania County, Virginia. Budworms collected from these sections were taken into the laboratory and reared. The number of worms collected and per cent parasitized, are shown in table 1.

A portion of a plant bed at Chatham was observed at intervals from June 14 through August 12—at which time practically all the tobacco in the field had been harvested. The per cent parasitism in this bed is shown in table 2.

The topping process, which consists of cutting off the top of the plant so that approximately 14 leaves are left on the plant, usually destroys most of the budworms. After the plants had been topped, a number of fields were re-examined. A total of 200 plants in four different parts of each field were examined closely for budworm injury (Table 3). A plant having 35 per cent of the leaf tissue on two or more leaves destroyed was classified as severely injured. Plants classified as slightly injured were those that had, at the most, only one severely in-

Table 2.—The per cent of tobacco budworms parasitized by *Sagaritis provancheri* (D.T.) in a plant bed at Chatham, Virginia.

DATE	NUMBER OF BUDWORMS[1]	PER CENT PARASITIZED
June 14	28	14.3
17	22	31.8
19	35	31.4
30	35	85.7
July 15	6	66.7
28	44	29.5
August 12	5	80.0

[1] A pupa of the parasite is considered as a parasitized budworm in making the survey.

Table 3.—The per cent of budworm injury on 200 plants in various tobacco fields in Pittsylvania County, Virginia, during 1942.

Field No.	Per Cent Injured		Total Per Cent of Injury
	Severely	Slightly	
1	3.0	5.0	8.0
2	5.5	8.0	13.5
3	3.5	8.0	11.5
4	2.5	5.0	7.5
5	3.5	5.5	9.0
11	4.5	9.0	13.5

jured leaf, although it might have 2 or 3 leaves showing a few budworms feeding.

Discussion.—Observations have shown that only one parasite can emerge from a parasitized budworm. Because of this, one is able to determine the number of parasitized budworms by counting the pupae of the parasites collected in the field.

Table 1 shows the percentage of budworm parasitism in various tobacco fields in Pittsylvania County. The percentage ranged from 27.6 to a high of 94.1. In the first field, 124 budworms were collected in three days. Only 27.6 per cent of these were parasitized. This same field was re-examined on July 6. Six of the 10 budworms collected at that time were parasitized. The parasitism in the remaining fields varied from 46.2 per cent to 94.1 per cent.

Table 2 shows the per cent of the budworm parasitism in a plant bed during the tobacco season. The first count, made on June 14, showed parasitism of 14.3 per cent. The population of budworms increased during June, and the parasitism also increased to 85.7 per cent. On July 15 only 6 budworms were collected and 4 of these were parasitized. In the next count, on July 28, 44 budworms were collected and only 29.5 per cent were parasitized. This was probably due to the fact that the budworms were feeding in the seed pods and probably were hard for the adult parasites to find. In all other budworm parasite surveys, both in the plant bed and in the field, only occasionally was a larva found larger than the third instar in growth. In the July 28th plant bed collection, 27 of the 33 larvae were fourth instar and larger in size.

As the budworm increases in size, it becomes more destructive since it requires more food. Therefore, a parasitized budworm killed in the second or third instar, will not do as much damage as an unparasitized individual allowed to reach the pupal stage. Six of the previously examined fields were examined for the degree of budworm injury. The results are recorded in table 3. As shown by the table, the majority of the plants were only slightly injured. Since all the fields but no. 11 had 50 per cent or more of the budworms parasitized (field No. 11 had 46.2 per cent), the data in table 3 would seem to indicate that the budworm parasite helped to reduce the severity of budworm injury.

Summary.—The tobacco budworm, *Heliothis virescens* (F.), is parasitized by *Sagaritis provancheri* (D.T.) in Virginia. All but one of the fields examined showed over 50 per cent parasitism during the survey, with the highest per cent parasitism being 94.1. This parasite kills the tobacco budworm in the second or third instar of growth, thereby preventing considerable damage to the tobacco plant.—2-1-43.

The Say Stinkbug on Potatoes in Montana[1]

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Potato plantings in northeastern Colorado suffered from attacks of Say's stinkbug, *Chlorochroa sayi* Stål.[2] during 1939. L. B. Daniels (1939) described the damage resulting from the feeding as a new potato disease. Two types of injury were noticeable. "A complete wilting of the leaves or tip of the plants" resulted from the feeding activity of the bugs. More general symptoms, similar to psyllid yellows, resulted when numbers of pentatomids attacked the basal portions of the stems. Color changes of the foliage, basal curling of terminal leaves, and abnormal tuber formation were associated with extremely heavy stinkbug infestations. The same writer (Daniels (1941)) mentioned the experimental use of Pyrethrum dust 10 per cent against the stinkbugs on potatoes and indicated the diseased condition might be due to poisonous secretions introduced by the insects while feeding.

The first Montana record of *Chlorochroa* attack on potatoes was contained in a letter from Mr. Ed. Isaac, Montana Extension Horticulturist, written July 24, 1939. (It is interesting to note that the first reports of damage in Colorado were received by Daniels on July 29, 1939). The reference to Say's stinkbug in Mr. Isaac's letter is quoted in full:

> "I ran into a new trouble in Chouteau County that I have not seen before. The farmer there complained of the Say's plant bugs bothering his potatoes. He said he found an average of 70 to a plant but these were not present at the time I was there. They had moved out into the grain fields. I must say they had plenty in the grain, about two bugs to every head of wheat and the farmer stated that was not near all of them that could be seen in the evening."

The severe infestation mentioned above was apparently unusual, as no additional reports of damage were received in 1939.

On August 1, 1940, stinkbugs collected from wheat fields were caged over two series of multiple-stemmed Bliss Triumph potato plants 14–16″ high. Each series consisted of five individually-caged plants on which were confined 0, 10, 25, 50 and 100 stinkbugs, respectively. On September 17 (46 days later) the cages were removed, dead and live bugs were collected, and the extent of damage to the plants was observed. These results are summarized in table 1:

Detectable injury to the plants was all of a local nature, *i.e.*, a complete wilting of some leaves or tips of the plants. On plants having only a few wilted leaves or terminals, injury was characterized as "slight." Plants showing "extensive" injury had one-third to one-half of the leaves or terminals completely wilted. Tuber formation under all plants was normal. On none of the plants was there systemic damage, as evidenced by any curling of leaves or abnormal coloration of foliage.

On June 20, 1941, Say's stinkbugs were numerous in three potato plantings within 20 miles of Billings,

[1] Contribution from Montana State College, Agr. Exp. Station. Journal Series No. 173.

[2] The species referred to in this article is the form commonly infesting grain in Montana, and since all previous references to the occurrence of this species in the State have been under the name *Chlorochroa sayi*, it is thought best to use this name pending clarification of the status of forms in the group.

Table 1.—The survival and effect of Say's stinkbug populations caged on potato plants.

	A		B		C		D	
	I	II	I	II	I	II	I	II
Original No. of bugs per plant- on 8-1-40	10	10	25	25	50	50	100	100
No. of bugs recovered 9-17-40								
Alive	3	3	20	18	19	7	47	45[2]
Dead	5	4	5	4	20	41	44	55
Total	8	7	25	22	39	48	91	100
Extent of detectable injury to potato plants[1]	None		slight		slight		Extensive	

[1] Check series I + II, without bugs, showed no injury.
[2] 14 live nymphs and many eggs were also recovered from this plant.

Montana (Yellowstone County). As many as 10 bugs were observed on single plants 10–15″ in height. Many plants harbored smaller numbers of bugs. The only damage evident in these plants was wilting of terminal plant growth or of individual leaflets. Stinkbugs were still present on many plants showing partial wilting of apical leaflets. Some plants on which the terminals were completely wilted no longer harbored any of the insects.

Bugs were located more readily by observation than by sweep samples taken with an insect net. Sweeping the foliage of 3500 hills yielded only four stinkbugs. Further damage was not noticeable in subsequent visits to the same fields from June 29 to September 6, but stinkbugs were occasionally seen. An additional 15,800 net sweeps (taken on potatoes during this period) yielded 60 adults and 5 nymphs. Several clusters of stinkbug eggs were found during examination of potato foliage for potato psyllids, and two clusters of eggs were found on the foliage of the nightshade, *Solanum nigrum*.

Caffrey & Barber (1919) considered wheat, barley, and rye most subject to depredations of Say's stinkbug. Potatoes were not mentioned as a host by these authors, nor by Jacobson (1936). In Montana populations of stinkbugs on potatoes have rarely been high, although adult bugs, as well as eggs and nymphs, have been taken at various dates during the growing season. Observed injury following pentatomid attack has been limited to localized, complete wilting of individual leaves or terminal growth. None of the systemic effects reported from the Colorado stinkbug infestations of 1939 have been observed in Montana, either under our infrequent moderate-to-heavy field infestations, or in the limited experiments with large pentatomid populations. On the basis of observations in Montana it is unlikely that *Chlorochroa sayi* presents a serious problem in the production of potatoes.—2-23-43.

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Cryolite Injury to Tobacco Seedlings

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In 1939 the authors reported promising results in the control of the corn root webworm, *Crambus caliginosellus* Clem., on newly set tobacco plants by means of poison dips applied to the stems and roots, and also to the entire plants, of seedlings prior to transplanting. Cryolite containing 85 per cent of sodium fluoaluminate was used at the rate of 3 ounces per gallon of water in experiments in which the entire plant was dipped, and 4 ounces per gallon when only the stems and roots were dipped. The water-cryolite mixture was tested alone and in combination with various supplements. After these preliminary tests had been completed the treatments were reported as having caused no plant injury.

Subsequent tests, made under different soil and weather conditions, with identical treatments and with similar treatments containing as little as 1 ounce of cryolite per gallon, resulted in severe plant injury, in some cases 90 per cent of the treated plants being damaged. In view of these results, it must be concluded that the cryolite treatments tested to date are not safe, under all conditions, for use on the roots of tobacco seedlings.—3-10-43

LITERATURE CITED

Scott, L. B., and Joe Milam. 1939. Cryolite dips as a control measure for the corn root webworm on newly set tobacco plants. JOUR. ECON. ENT. 32(3): 469.

Tests Using 1, 1-Dichloro-1-Nitroethane against Wireworms

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The compound 1,1-Dichloro-1-nitroethane was reported by O'Kane & Smith (1941) as a chemical with desirable qualities as a fumigant. Tests were conducted during 1942 to determine the value of this chemical as a soil fumigant for the control of wireworms. Preliminary studies following the method of Lehman (1933) showed the chemical to be very toxic to wireworms. Between 1 and 5 mg. in a liter of moist air will kill 100 per cent of 2- to 3-year-old larvae of *Limonius californicus* Mann. when exposed for 5 hours. Approximately 10 mg. will kill 100 per cent of the larvae when exposed in 500 g. of moist soil in a 1-liter flask for 5 hours, which indicates that this chemical is about 10 times as toxic as carbon disulfide.

Field tests to determine the diffusibility in Walla Walla silt-loam soil indicated that the chemical readily permeated the soil. It was found that as little as 0.5 ounce (approximately 15 cc.) was sufficient to kill all the wireworms in a 6-inch circle around the point of injection to a depth of at least 12 inches. In a 9-inch circle practically all the wireworms to a depth of 9 inches were killed. One ounce (approximately 29.5 cc.) killed slightly more, but the mortality was not in proportion to the amount of chemical used. The injections were made 1 inch deep and 1 inch in diameter. The wireworms were in wire-mesh cages in holes bored into the soil at 6, 9, 12, and 15 inches from the injection centers. The aver-

age results of six tests scattered throughout the season are given in table 1.

Table 1.—The average percentage of mortality of wireworms treated with 1,1-dichloro-1-nitroethane in 1942.

Depth in Inches	Mortality at Lateral Distance of—			
	6 Inches	9 Inches	12 Inches	Check
	Per Cent	*Per Cent*	*Per Cent*	*Per Cent*
Using 0.5 ounce per injection center:				
0–3	100	97	34	15
3–6	100	100	37	18
6–9	100	97	31	18
9–12	100	77	26	22
Using 1.0 ounce per injection center:				
0–3	100	95	46	14
3–6	100	100	54	19
6–9	100	100	49	17
9–12	100	82	36	22

In submergence experiments in the laboratory a 0.01 per cent aqueous solution (by volume) killed 100 per cent of the larvae in soil in a 1-day exposure. All soil was saturated and submerged by a half inch of solution. A 0.001 per cent solution gave kills no better than the water used as a check. These results indicated that the limit of toxicity by flooding is about 100 parts per million.

In repellency experiments 25 larvae were placed at each of the various depths—1.5, 4.5, 7.5, and 10.5 inches—in separate galvanized-iron 1-cubic-foot containers filled with moist soil, to which 1,1-dichloro-1-nitroethane was added in a hole a half-inch deep and 1 inch in diameter, in the center of the surface of the soil. In the 5-cc. treatment 13 per cent were found in the top 6 inches, 23 per cent in the 6- to 9-inch layer, and 64 per cent in the 9- to 12-inch layer, and all were dead. When 7.5 or 10 cc. was used, 87–88 per cent were found in the 9- to 12-inch layer, all being dead. In the untreated check 22–28 per cent were found in each 3-inch layer, and all but 1 were alive. This indicates that the material is repellent and does not kill rapidly enough to prevent the larvae from trying to escape.

Germination tests, in which cucumbers, cantaloups, onions, peas, and corn were tested by placing the seeds in petri dishes on cellucotton saturated with the test chemical, showed that a 0.1 per cent solution of the chemical had no detrimental effect on cucumbers or cantaloups, whereas onions, peas, and corn were slightly retarded. A 0.01 per cent solution was not harmful to germination of any of these seeds. In many cases the root growth with 1,1-dichloro-1-nitroethane was slightly greater than with water alone.

In field tests, in which the chemical was applied to the furrow a half-inch below the seeds, the chemical showed definite protection to peas and cucumbers from wireworm damage. In the other crops tried the protection was less marked. The most effective quantity was 2 cc. per foot of row, applied under the seeds. An application of 5 cc. produced severe injury. Little advantage was gained when the chemical was applied to growing plants, and damage was severe when the 1,1-dichloro-1-nitroethane touched the stem or the foliage.—2-19-43.

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The Larva of *Culex abominator* Dyar & Knab

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Culex abominator was described briefly by Dyar & Knab (1909) and more in detail by Howard, *et al.* (1915). The type series contained specimens from Tutwiler, Mississippi; Rives, Tennessee; Como, Louisiana; Victoria, and Plano, Texas. However, it was later determined that the larvae and possibly the adult female descriptions were actually those of *C. erraticus*. *C. erraticus* was described from larval characters by Dyar & Knab in 1906, and the female was described in 1915. As the male of this species was unknown, on the basis of the similarity of the female, *C. abominator* was made a synonym of *C. erraticus*, and the male characters of *C. abominator* adopted for the species. In Dyar (1928) *C. abominator* is listed as a synonym of *C. erraticus* and *C. abominator* terminalia is used in the *C. erraticus* description.

This confusing situation was cleared up in 1937 when King & Bradley studied the type specimens in the National Museum, as well as a few specimens collected near Stephenville, Texas, in 1933, and declared *C. abominator* a valid species with the larvae unknown. The specimens from Stephenville, Texas, had been identified as *C. erraticus* on the basis of similarity with Dyar's male characters given for that species.

Culex abominator larvae were first taken by the author and D. C. Thurman,[1] August 7, 1942 in a collection of larvae taken from a roadside pool near New Braunfels, Texas. Due to the presence of willow trees and aquatic plants, it was noted that the pool was a permanent one rather than temporary rain water. However, a recent rain had increased the amount of water and accounted for the presence of the *Psorophora* larvae encountered. The pond abounded with minnows and other predators but overhanging grass afforded sufficient protection for large numbers of larvae.

The larvae collected were identified as *Psorophora ciliata*, *P discolor*, *Anopheles punctipennis*, and *Culex erraticus*. The *Culex* were isolated and as they all appeared to be *C. erraticus*, only a few specimens were examined and the rest left to complete their development.

A week later the *Culex* began to pupate and it was noticed that some of the pupae were considerably smaller than the others. Upon examination of the remaining larvae it was determined that some of them were *C. erraticus* with typical upper head hairs short and multiple, while several larvae had double upper head hairs and seemed to fit the description of *C. peccator*. These larvae were isolated and upon emerging they were identified as *C. abominator* ac-

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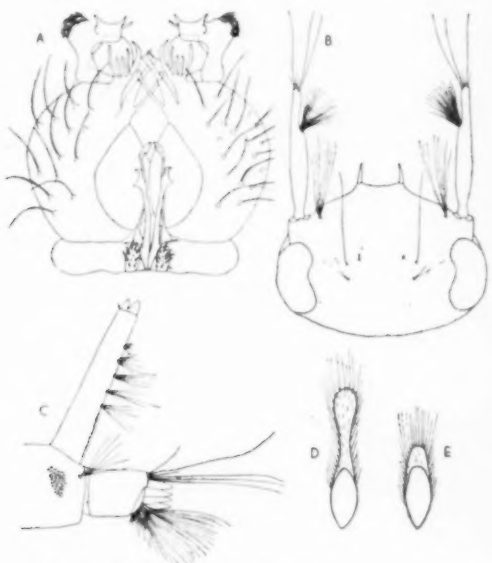
cording to their male terminalia. This identification was kindly verified by Dr. Alan Stone, U. S. National Museum.

Two other collections were made from the same pool on September 13 and October 23, 1942, and approximately a hundred *Culex abominator* were taken. *C. tarsalis* and *C. erraticus* were also breeding abundantly in the same pool. About the middle of September a number of larvae were received for identification at the Laboratory from Kelly Field, San Antonio, Texas. There were 25 or 30 *C. abominator* in this group.

There is little reason to confuse *Culex abominator* and *C. erraticus* as the larvae are quite different and the male terminalia are radically different. The larvae can be separated macroscopically by their shape and color. *C. abominator* are smaller and more slender than *C. erraticus*. This is especially noticeable in respect to the head and thorax. Each abdominal segment is ringed with scattered black pigment, giving a speckled dark grey and white appearance. This marking is most prominent on segment 2, 3, 5, 6, and 8 and has been a constant character on all of the *C. abominator* examined. *C. erraticus* has a large, broad head and thorax, and there is a wide variation in color which includes all shades of green and black. *C. erraticus* larva has half as many comb scales (15–20) as *C. abominator*, and the individual comb scales are three times as long as those of *C. abominator*. The upper head hairs of *C. erraticus* are multiple while those of *C. abominator* are single or double.

However, *Culex abominator* is quite similar to *C. peccator* in all stages. *C. abominator* terminalia has the subterminal filament extended beyond the claw of the clasper, the apex of the clasper below the claw is rounded, side pieces with scattered large hairs, and the rest of the clasper has a solid fused horn. In *C. peccator* the crest of the clasper has a group of separate spines, the subterminal filament is small and delicate, the apex of the clasper just below the claw forms a square point, and the side pieces are densely clothed with fine hairs, centrally located on the lower surface.



A. Genitalia of *Culex abominator*
B. & C. Larva of *C. abominator*
D. Comb scale of *C. abominator* (0.025 mm. average length)
E. Comb scale of *C. peccator* (0.04 mm. average length)

The two larvae appear to be very closely associated from a study of the limited material of *Culex peccator* available. The shape and size of the pectin teeth and comb scales are somewhat different (Plate 1, fig. D and E), and *C. abominator* appears to be more nearly glabrous than *C. peccator*. The individual comb scales of *C. peccator* are about twice as long as those of *C. abominator*. However, the male terminalia are useful, if not necessary, in definitely separating the two species.

Type specimens of *Culex abominator* larvae are in the Texas State Department of Health mosquito collection.

Culex abominator Dyar and Knab

Culex abominator Dyar and Knab, Smiths. Misc. Coll., Quart. Iss., **52**: 257, 1909.

Culex abominator Howard, Dyar, and Knab. "Mosq. North and Cent. America and W.I.," **3**: 378, 1915. (The male description was *abominator*, the larva and female *erraticus*).

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Culex erraticus Dyar. "Mosq. of Americas." Carnegie Inst. Wash. Pub. 387, 616 pp. illus., 1928. (*abominator* listed as a synonym of *erraticus*.)

Culex abominator Dyar and Knab, Annals of Eng. Soc. of Am. **30**: 345–357, illus. (*abomniator* declared valid species by King and Bradley).

Fourth stage larva (Fig. 1—B, C): antennae large and spinose, about as long as the head, slightly swollen on the basal two thirds, the apical third more slender, a large multiple tuft at outer third, at tip three terminal setae half as long as the antennae, a short spine, and a shorter blunt digit. Preantennal hairs usually eight in number and sparsely feathered. Upper heard hairs double or single (usually double) and about one half as long as the single lower head hairs. Postclypeal hairs half as long as upper head hairs and single or double. Mental plate triangular, with a large central tooth and six teeth on each side.

Thorax and abdomen sparsely spiculate to glabrous. Lateral abdominal hairs a single and a double on segment one, double on segment two, and triple on segments three to six.

Lateral comb of eighth segment 35 to 40 scales in an elongate patch, three or four rows deep (usually four) centrally (Fig. 1—D). Air tube about five times as long as its width at its base, tapering toward its apex. Pectin of 18 to 20 evenly spaced teeth on basal third. Five pairs of hair tufts ventrally beyond the pectin, evenly spaced. The tufts are progressively shorter from the base. The basal pair of tufts about twice as long as the fifth pair. Anal segment as long as wide, ringed by the plate, anal gills about half as long as the anal segment, tapering to a blunt point.

Genitalia (Fig. 1—A): "Side-pieces much enlarged, subspherical, excavated on inner side, as broad as long; inner process divided, outer part columnar, bearing four rods with hooked tips and a large, distorted leaf-like appendage; inner portion furcate, inner limb very short, each bearing a filament with curved and expanded tip; clasp filament large, slightly constricted beyond middle, inflated at outer third and bearing a row of hairs outwardly, a

stout claw before tip, tip pointed and bearing a stout inserted spine. Harpes with inner branch long and slender, bearing a few spines at tip. Harpagones divided into several lamellae, all rather small. Basa appendages minute, elliptical, oblique, setose. Last segment of abdomen divided along ventral line, widely open posteriorly."[1]—12-11-42.

[1] Howard, Dyar, and Knab, 1915, illus., original.

Tests of Mississippi Bentonites in Tank-mix Nicotine Bentonite Sprays for Control of the Codling Moth

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One of the most serious objections to the tank-mix nicotine bentonite-soybean oil spray mixture (Steiner et al., 1939), which has been found very effective for control of the codling moth, *Carpocapsa pomonella* (L.), in the Middle West, has been the heavy bentonite residue which at times remains on the apples at harvest, and which is sometimes difficult to remove. After several years of effort to overcome this difficulty, the authors have found that mixtures prepared with certain untreated Mississippi bentonites, instead of the Wyoming types formerly used, are highly effective and do not leave objectionable residues.

Maximum resistance to weathering and maximum visibility of deposit are associated with the Wyoming bentonites, which swell to 8 or more times their original volume when wet with water. The Mississippi bentonites swell to not more than 3 times their original volume. Approximately 8 pounds of those used in the tests reported herein will remove 90 per cent of the nicotine from a water solution of 1 pint of nicotine sulfate (40 per cent) and 100 gallons of water, or the same as 5 pounds of the Wyoming bentonite studied by Fahey (1941).

Experiments were conducted by the laboratory-field method (Stiner 1939) on the Grimes Golden variety and by single-tree plots replicated 7 times in a restricted randomization on the Rome Beauty variety. All plots were sprayed alike at petal-fall with a mixture of 3 pounds of lead arsenate, 3 pounds of lime, and 6 pounds of wettable sulfur per 100 gallons of water. Eight cover sprays were applied to each series of nicotine plots from tower and ground at 500 pounds' pressure. A lead arsenate plot was given 7 cover sprays. The trees were sprayed thoroughly to the point of run-off, an average of 25 to 30 gallons per tree being required at each application. An extra application of 10 gallons per tree was made between the third and fourth cover sprays to the tops of the nicotine-sprayed trees in the replicated series. The first cover spray was applied May 13 and the last on August 24, with harvest beginning on September 21.

The treatments tested in 1942 are listed in table 1, which summarizes the data from the laboratory-field experiments with the nicotine mixtures on Grimes Golden. Quantities given are for each 100 gallons of spray mixture.

Infestation data from the replicated field tests are given in table 2.

[1] The writers were assisted in these investigations by S. A. Summerland and H. W. Rusk.

Table 1.—Treatments applied and average spray deposits and per cent larvicidal efficiencies for nicotine bentonite treatments after spray applications and after periods of weathering. Laboratory-field experiments on Grimes apples, Vincennes, Ind., 1942.

Plot No.	Treatment for First Brood (4 Applications[1])	Treatment for Second and Third Broods (4 Applications)	After Spraying: Nicotine Deposit Mgs. per Sq. Cm.	After Spraying: Nicotine Deposit Efficiency Per Cent	After Weathering: Nicotine Deposit Mgs. per Sq. Cm.	After Weathering: Nicotine Deposit Efficiency Per Cent
1.	Lead arsenate, 4 lbs. Mineral oil, 2 qts.[2] Copper sulfate, 0.75 lb. Lime, 1.5 lbs.	Lead arsenate, 3 lbs.[3] Copper sulfate, 0.75 lb. Lime, 1.5 lbs.	—	—	—	—
2.	Nicotine sulfate, 1 pt. Wyoming bentonite, 5 lbs. Crude soybean oil, 1 qt.	Nicotine sulfate, 0.67 pt. Wyoming bentonite, 3.33 lbs. Crude soybean oil, 1 qt.[4]	6.2	89	3.2	75
3.	Nicotine sulfate, 1 pt. Miss. bentonite, 5 lbs.[5] Mineral oil, 2 qts.[6]	Nicotine sulfate, 0.67 pt. Miss. bentonite, 5 lbs. Mineral oil, 2 qts.[7]	5.8	90	2.4	75
4.	Same as plot 2	Same as plot 3	6.3	92	2.9	78

[1] Plus extra top-off spray on nicotine plots in replicated field tests.
[2] Mineral oil omitted from first cover.
[3] Only 3 applications.
[4] In last application the following was substituted: Nicotine sulfate, 0.67 pt.; Wyoming bentonite, 0.5 lb.; Mineral oil, 2 qts.
[5] 8 pounds used in 3rd and 4th cover sprays.
[6] 1 qt. Soybean oil used in 1st application.
[7] 1 qt. in 5th application.

Table 2.—Infestation data from dropped and picked Rome Beauty apples. Vincennes, Ind., 1942.

Plot	Treatment[1]	Average Number per Tree		Seasonal Data		
		Apples	Worm Entrances on June 17	Per Cent Clean Apples	Number per 100 Apples	
					Worms	Stings
1.	Lead arsenate	3,197	9.1	83.8	5.3	18.8
2.	Nicotine bentonite (Wyo.)	4,814	34.0	88.2	4.9	8.3
3.	Nicotine bentonite (Miss.)	2,994	4.0	88.3	5.6	8.6
4.	Nicotine bentonite (Wyo. 1st brood, Miss. 2d and 3d broods)	3,939	37.1	84.3	8.0	11.6
Least significant difference at odds of 19 to 1		1,236	29.0	5.2	3.1	7.9

[1] Details of treatments the same as given in table 1.

The larvicidal efficiency and deposit data indicate that the Mississippi bentonite (plot 3) produced deposits that were lighter and less resistant to weathering but were as efficient as those of the Wyoming bentonite (plot 2).

The replicated plots were subjected to a heavy population carryover from 1941, when nearly 100 per cent of the fruit was injured in part of the block. Cool, rainy weather prevailed in May and June, 1942, making conditions unusually favorable for control with lead arsenate and increasing the ovicidal effectiveness of all combinations containing mineral oil.

Because of interplot migration of moths, the control that was obtained by the contact and poisoning effects of the nicotine sprays on the moth population was more or less distributed over the entire block, and not reflected in the data from the plots where it was produced. These treatments were further handicapped by spray drift from lead arsenate-bordeaux sprays, and by the unusually hard orchard well water, which decreased the proportion of insoluble nicotine in mixtures for the standard treatment to 75.4 per cent. The experimental block also included 3 lead arsenate and 3 nicotine bentonite plots in addition to those discussed herein and was surrounded by trees sprayed with lead arsenate.

Our experience has indicated that nicotine bentonite spray programs that give control equal to that of lead arsenate in small-plot tests give still better comparative results on acreages large enough to minimize the effects of moth migration (Steiner 1940).

No foliage injury occurred to any of the nicotine plots. Lead arsenate produced serious foliage injury in 1942.

All visible bentonite residues were readily removed from the fruit from plots 3 and 4 by brushing. An objectionable amount of bentonite residue remained in the stem and calyx ends of fruit from plot 2 after brushing. Fruit from plots 2, 3, and 4 was superior to that from plot 1 in both finish and color. The control of such pests as leafhoppers, apple leaf miners, and aerial colonies of the woolly apple aphid in all nicotine plots was equally good.

In supplementary laboratory-field tests, two bentonites from Mississippi were compared with one from Georgia. Only the sprays with Mississippi bentonites gave results equal to those with Wyoming bentonite. The Georgia bentonite was less effective in removing nicotine from water solutions, but several bentonites from other regions approximate the Mississippi products physically and chemically and may prove suitable with proper adjustments in formulas.

The results of the tests reported herein are believed to be promising enough to warrant large-scale field tests in 1943, when allowance is made for deficiencies of the small-plot method of testing codling moth treatments.—1-12-42.

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Performance of American Foulbrood Resistant Strain of Honeybees in New Jersey[1,2]

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For many years the American beekeepers have been searching for more effective methods of combatting American foulbrood, the major disease of the honeybee. In recent years, observations by practical beekeepers indicated that certain colonies of bees appeared to be able to cope with this disease more successfully than others. This observation suggested the possibility that careful selection, breeding and testing might produce a strain of bees which had an immunity or high resistance to American foulbrood. Reports in the Bee Journals concerning the success of certain commercial beekeepers in controlling American foulbrood in their apiaries by selective breeding programs probably was responsi-

[1] Journal series paper of the New Jersey Agricultural Experiment Station, Rutgers University, Department of Entomology.
[2] Eastern Branch Program, New York, November, 1942.

ble for arousing the interest of beekeepers in general to the possibilities of such a program. In 1934 the American Bee Journal made the first start in such a program by collecting from various parts of the country colonies of bees which the owners claimed had exhibited resistance to American foulbrood. Testing work during the following year indicated that certain colonies exhibited a degree of resistance to this disease. At this point, the Iowa Agricultural Experiment Station cooperated in the project and a few years work demonstrated, that resistance to American foulbrood did exist in honeybees and that the factor for resistance could be transmitted to the offspring. At this point, 1937, the Texas Agricultural Experiment Station and the U. S. Bureau of Entomology and Plant Quarantine became cooperators in order to expedite the progress of the project. The careful selection and breeding of this resistant stock for several years resulted in a consistent increase in the per cent of offspring which exhibited resistance characteristics. By 1940 the various cooperators decided that the development of this resistant strain of bees had progressed to a point where limited numbers of this stock should be released to the state agencies that wished to test this strain of bees under their conditions.

The New Jersey Agricultural Experiment Station cooperated in this program and received for testing purposes 12 queens each year for the period 1940, 1941 and 1942. In releasing these queens the cooperating agencies made no guarantee of their disease resisting or honey producing performance nor did they specify any definite procedure to be followed in the testing of this stock. Other than the suggestion that a full report of the performance of this stock be sent to the cooperating agencies, the state agencies were free to test this stock in any way they desired. The method of testing followed in New Jersey was based on procedures reported by Iowa Agricultural Experiment Station investigators in earlier publications on this project. Briefly, the procedure consisted of introducing the queens into 3 frame nuclei which were made up from disease free colonies. The queens were allowed to head these nuclei for a period of 6 to 8 weeks to insure that the bees making up the colony consisted primarily of offspring of the tested queen. The colony was then inoculated with American foulbrood by the comb insert method. A comb insert containing from 40 to 100 dry scales of larvae dead from American foulbrood was introduced into the brood nest of each colony used in these studies during the 1940 and 1941 seasons. Following inoculation the colonies were examined at frequent intervals to note their efforts in resisting this infestion of disease.

The results obtained in 1940 are interesting and were very encouraging at the time. Resistant queens were introduced to colonies on June 20 and the colonies were inoculated with disease on August 8 by the comb insert method. In a majority of the colonies the remains of the diseased larvae in these inserts had been entirely removed by August 10. Two distinct methods of removal of the dead larvae in the comb inserts were noted. In some colonies the diseased remains were removed bit by bit without damaging the cells, while in other colonies the entire cell walls were torn down in the removal process. These observations are in agreement with earlier ones reported by investigators at the Iowa Station (Park *et al.* 1937) on the variation in the way different colonies react towards the comb inserts containing American foulbrood. Frequent examination during the remainder of the 1940 season showed no evidence of disease in these colonies which seems to indicate that these colonies exhibited considerable resistance to American foulbrood. All of these colonies were successfully carried through the winter period and examinations of the broodnest during March and April of 1941 showed all but one colony to be free of disease. An examination of colonies early in May presented a much different picture from the disease angle, as only 3 of the 11 colonies headed by this stock were free of disease. Later all of the colonies became so badly diseased and were weakened to an extent that they had to be discarded by early September. The behavior of these colonies during the early summer of 1941 was rather disappointing after their favorable reaction to the disease in 1940 and considerable time was spent in an effort to find an explanation for this apparent reversal of form.

Observations during the 1941 season disclosed that the time required for diseased larvae to dry down into a dry scale was considerably longer under New Jersey conditions than had been reported to be the case by Woodrow (1941) in his work in Wyoming. Woodrow states, "Following the removal of the cell cappings by the bees, the discolored, melting brood dried down rapidly and passed into a fairly firm scale condition in from 3 to 5 days, but the drying process proceeded somewhat more slowly in cells remaining capped longer" and "Most of the diseased brood passed into the scale stage approximately 2 to 3 weeks after being sealed, or 3 to 4 weeks after the eggs were laid." Under New Jersey conditions in 1941, larvae dead of American foulbrood remained in a moist semisolid state for a period of from 20 to 35 days after the cells containing the larvae were uncapped by the bees. This would be equivalent to a period of from 4 to 6 weeks after the cells had been sealed and a period of 6 to 8 weeks after the eggs were laid. Under New Jersey conditions worker bees attempted to remove these diseased larvae before they dry down into scales. Worker bees were observed to tear out portions of the jelly-like dead larvae with their mandibles and to suck up the body juices with their tongues in their efforts to remove the diseased larvae. Under these conditions, the mouthparts of the house bees apparently became contaminated with disease material, and the disease spreads rapidly throughout the broodnest. The fact that these colonies were able to remove the dry scales of larvae dead of American foulbrood without spreading the disease throughout the broodnest indicates that the mouthparts of the bees do not become greatly contaminated in the removal of dry scale material and it is very probable that only the mandibles are involved in this process. Throughout these observations the resistent strain of bees constantly exhibited a much more persistent and determined effort to remove dead larvae from the broodnest than any of the local strains of bees under observation. These observations tend to support the findings of other investigators, that the resistance to American foulbrood exhibited by this strain of bees is not true immunity but is due to certain house cleaning characteristics of the bees. The performance of this strain of bees under New Jersey conditions indicates that the effectiveness of their house cleaning activities in eliminating American foulbrood is dependent to a large extent upon the rapidity with which the dead larvae dry down down into a firm scale. This suggests that this strain of bees might exhibit satisfactory resistance to American foulbrood in those sections of the country

where conditions are favorable for the rapid drying of the dead larvae, which were not possible under New Jersey conditions. Based on our experiences with the colonies headed by the resistant queens obtained in 1940 and 1941, we have concluded that further selection and breeding is necessary to produce a satisfactory American foulbrood resistant strain of honeybees to meet New Jersey conditions.

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Attraction of Melanophila Beetles by Fire and Smoke

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During the last few years the writer has received an increasing number of complaints from sawmill operators, fire fighters and smelter plant workers regarding annoyance by buprestid beetles of the genus *Melanophila*. These beetles appear to be greatly stimulated by heat and attracted by smoke. They normally breed in fire scarred pines and under ordinary conditions they are rarely encountered in nature. However, on hot days during the dry season, especially in late summer and fall, they sometimes fly in unbelievable numbers to forest fires, burning refuse dumps, refineries, smelter plants, etc.

The reaction of *Melanophila* to smoke and burning wood has been noticed by several writers. The earliest record that I have been able to find is that of Ricksecker (1885) who found a swarm of many hundreds of *M. consputa* Lec. and *M. longipes* Say (=*acuminata* DeG.) where a brush fire had scorched some young Douglas firs (*Pseudotsuga taxifolia*) in California.[1] C. G. Champion (1909) also called attention at an early date to the breeding of *M. acuminata* (DeGeer) in burned pines in England and also reported adults resting on charred stumps both in England and Corsica. Later, Sharp (1918), speaking of the same species encountered at a burning pine stump, writes " . . . scorched by the burning peat, and half choked by the blinding smoke, we added quite a novel episode to our experiences in collecting beetles, for on the ground on which it was too hot to place one's hand, many *Melanophila* were running. They were settled . . . on pine stumps actually glowing, or flying under a blazing August sun through drifts of acrid peat smoke . . . ." Manee (1913) recorded the flight of two American species, *M. notata* (Cast. & Gory) and *M.* sp. (probably *opaca* Lec.) to a blazing pine stump in North Carolina. The beetles were alighting on clothing, ashes, and nearby wood. Manee learned that the natives called them "fire bugs," believing them to actually "come from the fire and to contain such heat as to burn the skin should they rest upon it." An Indian species, *M. ignicola* Champ., was found by H. G. Champion about a distillation plant for production of tar from resinous pine stumps. They were taken flying about the "plant" and settling on and running over tarry pipes and tanks ("which were almost too hot to touch") and on the heated masonry. Van Dyke (1926) has recorded the swarming of *M. consputa* Lec. at a 750,000 barrel oil fire at Coalinga, California. A remarkable feature of this case is the fact that Coalinga is in an arid region more than fifty miles from the nearest coniferous forest which could have provided the source of the beetles. A similar occurrence has been noted in southern Arizona (Linsley, 1933) where three species, *M. acuminata* (DeGeer), *M. notata elegans* Sloop, and *M. consputa* Lec. were apparently drawn over a comparable distance by the acrid fumes of a large smelter plant at Douglas. *M. consputa* has also been reported (Van Dyke, 1928) in large numbers about a sugar refinery in San Francisco, congregating about storage vats containing hot sugar or syrup (no mention was made in this case of the presence of smoke or fumes associated with the refinery although they may have existed). As a further observation on *Melanophila* beetles, I may add that at football games in the California Memorial Stadium at Berkeley they occasionally swarm in sufficient numbers to annoy patrons by alighting on the clothing or even biting the neck or hands. It is possible that in this case the beetles are attracted by the smoke from some twenty thousand (more or less) cigarettes which on still days sometimes hangs like a haze over the stadium during a "big" game. The beetles seen at the football games were *Melanophila consputa* Lec. and *M. acuminata* (DeGeer), both of which breed in fire scorched pines in the hills adjacent to the stadium. A third species *M. occidentalis* Obenberger, has been taken on partly burned eucalyptus at Berkeley, although it is not known to breed in this host.

When the cases cited above are examined, two common denominators are evident, smoke (and associated volatile materials) and heat. Light can probably be eliminated as a factor since the *Melanophila* are diurnal (despite their name!) and unusual light is not evident in all of the cases mentioned. However, at Douglas, Arizona, the beetles, having been attracted to the general area by smelter fumes, were secondarily attracted to bright lights of the city under the stimulus of a very hot evening; the only occasion on which the writer has encountered buprestids either flying at night or attracted to lights. Sharp (1918) was inclined to regard heat as the critical factor. He stated that he was "convinced that these beetles thoroughly enjoyed a temperature too high for the existence of any living thing, except a Dipteron (the empid, *Hormopeza obliterata* Zett., *fide* Collin 1918) which appeared to share their habitat . . . ." He continues later " . . . we may explain its morphology and colour, but not the development of the singular attraction which heat has for the insect." Although not dismissing the possible role of heat, especially as a stimulant in close proximity to the source, the rapidity with which heat dissipates in the open, argues that the primary response is probably olfactory, directed toward the volatile materials associated with smoke. Attention has previously (Linsley 1933) been called to the fact that all of the forms which have thus far been noted

[1] An interesting observation of Ricksecker's, which has not to my knowledge been confirmed by any subsequent observer, was that while watching a swarm of these *Melanophila* about a large, partly decayed Douglas fir which had been subjected to heat and partly slipped its bark, he observed four different individuals devour scorched termites (probably *Zootermopsis*), the first instance of a carnivorous habit in the Buprestidae. In confinement, however, Ryle (1923) noted that adults of *M. acuminata* drank sugar syrup and ate the abdomen of a dead *Tortrix*.

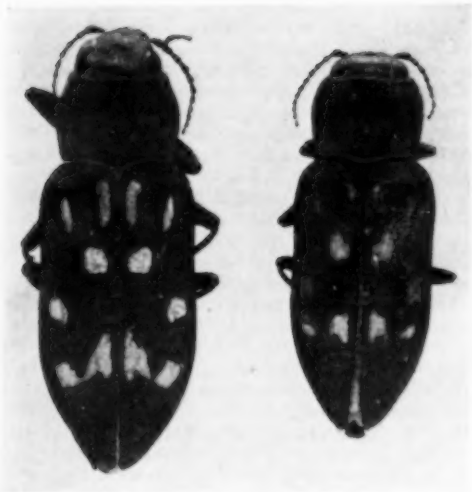

FIG. 1.—The spotted fire beetle, *Melanophila consputa* Lec. ×5.

as reacting to smoke belong to the narrow, flattened group of species (subgenus *Melanophila* s. str.). Other species (subgenus *Phaenops*) do not behave in this manner. In a recent revision of the genus, Sloop (1937) has revealed the presence of two small pits contiguous to the lateral margin of the middle coxae which appear to be of a sensory nature. He suggests that the presence of these "sensory pits" in the subgenus *Melanophila* and their absence in the remaining subgenera may be correlated with the attraction of species by smoke.

A further question may be raised as to the possible selective value of this remarkable habit in the survival of the species. The only comment which I have noted on this point is that of Nicholson (1919), who remarks that *Melanophila acuminata* (DeGeer) is the only Buprestid of its size that has been able to establish itself in England and it must therefore possess some advantage not shared by others of its group. This advantage, he claims, is to be found in the fact that it spends its existence in wood which has recently been subjected to an amount of heat sufficient to kill all competitors. The fallacy of this argument lies in the fact that the beetles usually oviposit on green wood which probably harbored few if any competitors prior to being subjected to fire. Thus any advantage over competitors would be of a temporary nature and would result from the fact that *Melanophila* is the first to oviposit on fire injured wood, not from the prior destruction of competitors. A more reasonable explanation would seem to be that after the *Melanophila* have become established, the charcoal, ashes, etc. serve as a deterrent to many potential competitors and natural enemies. This advantage, coupled with the fact that fires provide a convenient source of freshly killed wood (many wood borers, such as *Oncideres*, *Oberea*, etc., must provide this source themselves) is probably of sufficient selective value to account for the persistence of the habit. In fact, recent work has shown that living, uninjured trees are very resistant to successful attack by *Melanophila*, especially to *M. californica* Van Dyke (Graham, 1939: 226). Balanced against these possible advantages are several disadvantages, however. Sharp (1918) observes "we found pairs of this beetle . . . on timber whose complete destruction by fire seemed imminent,—and if oviposition took place in such a situation it is evident that a very serious risk of a similar fate would be run by any resulting progeny." The present writer believes, but was unable to verify, that he observed oviposition under conditions similar to those described by Sharp, although apparently the beetles normally mate under the stimulus of the fire and remain in the area afterwards for oviposition. On more than one occasion, however, beetles were seen to fly into the fire or be destroyed on burning coals, and the probabilities are that under conditions of forest fires the loss of individuals by this method must be great. In addition, the migration of large populations away from their breeding area under the stimulus of smoke from fires of non-coniferous origin must be very destructive to the species.

In summary, the buprestid beetles of the subgenus *Melanophila* s. str. appear to be attracted over long distances by smoke from a variety of burning materials, including wood, oil, mill refuse, smelter products, and possibly tobacco. In nature this attraction leads them to forest fires where they normally oviposit in scorched coniferous wood. The beetles are also stimulated by heat and in the vicinity of the source they fly rapidly and run about over hot surfaces. Light probably plays little if any role in their attraction to fires.—1-19-43.

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Control of Aphids and Diamond-Back Moth Larvae on Collards with Rotenone-Nicotine Dusts

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In the fall of 1941 a heavy infestation of cabbage aphids, *Brevicoryne brassicae* L., of green peach aphids or spinach aphids, *Myzus persicae* (Sulzer) and of the larvae of the diamond-back moth, *Plutella maculipennis* (Curtis), developed on collards and kale in the Norfolk area. Walker & Anderson (1937, 1939) and others have shown that the larvae of the diamond-back moth can be controlled by repeated applications of derris and cubé dusts, at 7- to 10-day intervals, whereas single applications have not been very effective; also that the aphids can be controlled with nicotine dust. The question arose as to whether or not a combination nicotine and rotenone dust would control the aphids and the larvae of the diamond-back moth.

Brooks & Allen (1940) obtained good control of cabbage aphids and of cabbage worms with a dust containing 25 pounds of derris, 37.5 pounds of lime, 37.5 pounds of sulfur and 5 pounds of nicotine (*Black Leaf 40*). Fulton & Nelson (1941) showed that cubé powder was not as adversely effected by an alkaline medium (a 4-6-50 bordeaux mixture) as many had thought it would be.

The test discussed herein was designed to compare the effectiveness of several nicotine, derris, derris-nicotine and derris-pyrethrum dusts for the control of these pests. The dusts were applied at the rate of about 40 to 45 pounds per acre with an 8-nozzle traction duster on November 11 and 18, 1941. The duster was equipped with a cloth trailer about 30 feet in length to confine the dust around the plants. While the dusts were being applied on November 11th the temperature was 53° F., the relative humidity was 52 per cent and the wind was blowing about 5 miles per hour. On November 18th the tem-

[1] The authors wish to express their appreciation to William Ralston, Tobacco By-Products and Chemical Corporation, Richmond, Virginia, for supplying the nicotine and for his help in conducting this test.

Table 1.—Results of dusting collards with nicotine, rotenone, and nicotine-rotenone dusts for the control of the green peach aphid (spinach aphid) and the diamond-back moth.

Dusts Tested	Per Cent Nicotine	Per Cent Rotenone	Average Number per Leaf of Diamond-back moth		Average Number per Leaf of Spinach aphids	
			Nov. 17	Nov. 22	Nov. 17	Nov. 22
1. *Black Leaf 155* Hydrated lime	2.0		5.8	2.7	30.3	20.5
2. *Black Leaf 155* Hydrated lime	3.0		5.4	2.3	14.1	4.3
3. *Black Leaf 155* Derris powder Hydrated lime	2.0	0.75	2.1	1.4	6.8	4.6
4. *Black Leaf 155* Derris powder Pyrophyllite	3.0	0.75	2.6	0.7	8.3	9.1
5. *Black Leaf 155* Derris powder Hydrated lime	3.0	0.75	1.3	0.3	4.6	0.7
6. *Black Leaf 10* Derris powder Pyrophyllite	2.0	0.75	2.0	1.3	10.1	13.2
7. *Black Leaf 10* Derris powder Pyrophyllite	3.0	0.75	1.4	0.7	2.5	0.9
8. Derris powder Pyrethrum (0.1% pyrethrins) Talc		1.0	1.6	1.2	32.6	29.2
9. Derris powder Pyrophyllite		0.75	2.3	0.6	45.4	51.8
10. Untreated check			6.4	5.7	85.5	105.1
Difference required for significance			1.7	0.9	21.5	20.5[1]

[1] When treatments 2, 3, 4, 5 and 7 were analyzed separately it was found that a difference of more than 3.9 between any of these treatments might be considered significant.

perature was 60° F., the relative humidity was 86 per cent and the wind was blowing about 3.5 miles per hour. Each treatment was replicated 3 times. The collards were fairly large and the leaves were overlapping in the rows, covering the ground. Counts were made of the number of diamond-back moth larvae and spinach aphids remaining on 45 leaves and 30 leaves on November 17th and 22nd, respectively. Actual counts of cabbage aphids were not made, but general observations showed that the degree of spinach aphid control was also a good index to the degree of cabbage aphid control.

The dusts used and the results obtained are given in table 1. *Black Leaf 155* is a fixed nicotine on a bentonite carrier containing 14 per cent nicotine, and *Black Leaf 10* is finely ground tobacco stems impregnated with 10 per cent by weight of free nicotine. The dusts were mixed on November 10th and thus had been mixed only 8 days when the second application was made.

As the *Black Leaf 155* is made especially for use in the control of the codling moth, *Carpocapsa pomonella* (L.), it was thought that possibly dusts made with it might control both aphids and the larvae of the diamond-back moth. However, it may be noted that the *Black Leaf 155* was not as effective as the derris dust in controlling the latter but was more effective in controlling the aphids. When the nicotine and derris were combined in one dust, there was a tendency for them to be more effective than the nicotine alone in controlling the aphids and more effective than the derris alone in controlling the larvae of the diamond-back moth. Also, there was a tendency for the hydrated lime to be a better diluent for the derris-*Black Leaf 155* mixture than pyrophyllite when used within 8 days after being mixed, as in this test. The derris-pyrethrum dust gave good control of the larvae of the diamond-back moth, but did not give satisfactory control of the aphids.

In addition to this test, several growers used *Black Leaf 10*-derris dusts and *Black Leaf 155*-derris dusts for the control of aphids and the larvae of the diamond-back moth on their kale and collards with very satisfactory results.—2-26-43.

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Apparent Control of the Pacific Mite with Xanthone

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An infestation of the Pacific mite, *Tetranychus pacificus* McG., developed in the three apple orchards used in 1941 for experiments in controlling the codling moth near Yakima, Wash., and some differences were evident in the degree of this infestation in the trees receiving different spray treatments. Each treatment had been applied to 8 trees in each orchard, scattered at random throughout the experimental block; hence, differences in the infestation of mites could hardly be due to the location of the trees in the orchard. Six cover sprays had been applied in two of the orchards (Rome and Winesap) between May 7 and August 9, and five cover sprays had been applied in the third orchard (Delicious) between May 19 and July 29.

About the middle of August each treated tree in all three orchards was carefully examined for mites. Since there were about 250 trees to be examined, it was impracticable to make any sort of careful count to determine the average number of mites per leaf or the percentage of leaves infested. The habits of the mites are such that any count of actual numbers would be of doubtful value. When the infestation has become heavy in a tree or portion of a tree, possibly because of a change in the condition of the leaves, many of the mites stop feeding, become orange colored, and migrate down the limbs and trunk. If an examination were made after this had happened, relatively few mites would be found on the leaves of heavily infested trees. The mites would be found chiefly on the limbs and trunks, where it would be impracticable to count them.

It was practicable, however, to make a careful appraisal of the degree of infestation in each tree by noting the prevalence of leaves that had become brown and were covered with webbing, the relative numbers of orange-colored migrating mites in the crotches of the trees, and the quantity of webbing spun on the trunks and particularly over the codling moth bands which were on the trees. This appraisal was backed by considerable experience on the part of the writer in making estimates of this type and is believed to be sufficiently accurate to give much weight to the conclusion drawn in this paper.

Since qualitative terms such as "light," "medium," etc., cannot be readily averaged, the various degrees of infestation occurring in the individual trees were arbitrarily given numbers. This makes it possible to show in a table the average infestations and to discuss them without circumlocution. The differences found are much more clearly and strik-

Table 1.—Degree of infestation of Pacific mite in apple trees sprayed with xanthone and other insecticides, Yakima, Wash.

YEAR	TREATMENT (Quantities per 100 gals.)	DEGREE OF MITE INFESTATION			
		Delicious	Rome	Winesap	Average
1941	Lead arsenate 3 lbs., mineral oil 1 qt., colloidal spreader 2.67 oz.	0.9	1.1	0.4	0.8
	Phenothiazine 2 lbs., stove oil 1 qt., soap 1.5 lbs.	0.4	0.6	0.1	0.4
	Xanthone 2 lbs., stove oil 1 pint, colloidal spreader 4 oz.	0.1	0.0	0.0	0.0
1942	Lead arsenate 3 lbs., mineral oil 1 qt., colloidal spreader 2.67 oz.	2.1	1.9	—	2.0
	Phenothiazine 1 lb., casein-stove oil emulsion (75% oil) 1 qt.	2.1	2.0	—	2.1
	Xanthone 2 lbs., casein-stove oil emulsion (75% oil) 1 qt.	1.1	1.1	—	1.1

ingly shown in this manner. No statistical treatment is necessary, or indeed possible, and the figures should not be considered from a statistical angle.

The figures used were as follows: (3), if large numbers of leaves were found covered with webbing and mites were migrating to the trunks in considerable numbers; (2), if only small numbers of infested leaves and migrating mites could be found; (1), if the infested leaves were very few and there was no migration; and (0) if no mites at all could be found after several minutes' search.

As shown in table 1 there was practically no mite infestation in 1941 in the trees that had been sprayed with xanthone. There was a very definite infestation however, in trees sprayed with lead arsenate and also in trees sprayed with phenothiazine with which was used twice the quantity of stove oil that was used with the xanthone. Thus the low infestation in the trees sprayed with xanthone cannot have been due to the stove oil used with it. There were four other tests of lead arsenate or phenothiazine in these orchards, all of which had average mite infestations of 0.3 to 1.9.

On account of this evident difference in infestation by the Pacific mite, records were also made in 1942 in two of the orchards, and these are also given in table 1. The infestation this year was much heavier, and another classification was added—(4), covering cases in which the foliage was heavily webbed and very large numbers of mites were migrating. These examinations were made late in July, following spray treatments similar to those of 1941 except that xanthone was first used in the third cover spray. These examinations show infestations in the trees sprayed with xanthone only half as heavy as in the trees sprayed with lead arsenate or phenothiazine. There were also three other treatments with phenothiazine which had average mite infestations of 2.0 to 2.3. On August 14 these trees were examined again, the trees in the meantime having had another cover spray. The infestation in the trees sprayed with lead arsenate had increased to 2.4, in the various treatments of phenothiazine it was now 2.4 to 3.8, but in the trees sprayed with xanthone it had increased only to 1.5. This was in spite of the fact that the mineral oil or stove oil used with the lead arsenate or phenothiazine had been increased in the intervening cover spray to 2 quarts, but had been kept at only 1 quart with the xanthone.

These records constitute a definite indication that xanthone hinders the development of the Pacific mite in apple trees. The difference was particularly striking in 1942. Most of the trees sprayed with lead arsenate or phenothiazine had a great deal of brown foliage, especially in the center of the tree, caused by the feeding of the mites, and the webbing on the trunks was evident from a distance. In the trees sprayed with xanthone, on the other hand, the foliage had remained green, and little or no webbing was evident. Whether this apparent control is sufficient to be of any practical value under various conditions remains to be seen.—1-11-43.

Plant Stimulation Aids in Control of *Pissodes nemorensis* on *Cedrus deodara*

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The following account on the control of the deodara borer has apparently proven satisfactory to hundreds of South Carolinians in the last ten years.

DAMAGE.—The deodara borer causes the well-known dying of branches of deodara and may, under certain circumstances, be responsible for killing entire trees. Moreover, the resin is a result of damage by this insect. Scarcely a deodara planting anywhere in South Carolina is to be found uninfested, and dozens of complaints are received annually by the extension entomologist.

NATURE OF INSECT.—The deodara borer is a snout weevil and has been reported feeding on pines. It is also a relative of the white pine weevil of the north. There are four steps in the development of the insect; namely, egg, larva or worm, pupa, and adult or weevil. The egg is laid under the bark of the tree, hatching into the worm which causes the resin to exude.

CONTROL.—Definite experimental information on the control of this insect is lacking; however, during a period of years observations indicate that damage to the trees may be largely prevented by stimulating growth. Growth may be stimulated by applications of commercial fertilizer or of compost and by watering when necessary during dry periods. It is a well-known fact that increasing the vigor of trees is one of the best means of preventing borer damage, and observations throughout the state indicate that this insect is not an exception. It is thought that invigorating the tree tends to increase the pressure of sap stream, thereby repulsing the invading insects. Certainly it would be difficult for any insect to survive the rapid flow of resinous material from a vigorously growing deodara.

NOTABLE EXAMPLE.—In a number of localities the effect of plant stimulation in protecting the deodara from the borers has been observed. One notable example is an old planting made about 1885 in Georgetown. When the writer was called in, six out of the eleven specimens were already dead. Several loads of compost and watering were advised. The dead and nearly dead trees were removed, and at the time of the last report the trees were in a very vigorous growing condition, having survived the attack.—1-19-43.

Life History of the European Chafer *Amphimallon majalis*[1] (Razoum)

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The European chafer, *Amphimallon majalis* (Razoum.), heretofore known only from Western Europe where it is a turf pest has become established in Southern Wayne County, New York. Damage so far observed there has been largely urban and has been mostly confined to turf. Numerous lawns in Newark have been injured or completely killed. Announcement of the presence of this pest in North America was first made by Gambrell, Mendall, and Smith (1) in 1942.

DISTRIBUTION.—During the period of adult flight in 1942 scouting carried on by the Bureau of Plant Industry of the New York State Department of Agriculture and Markets, and by entomological agencies at the Geneva and Cornell Experiment Stations, indicated that the infestation extends from Lyons to Palmyra in an east west direction, and from just north of Phelps to Fairville. An area of 140 square miles is therefore infested. The insect has not

[1] Eastern Branch Program, New York, November, 1942.

as yet been recorded from any other locality in the western hemisphere.

The adult, which in some respects resembles *Phyllophaga tristis*, can be distinguished from closely related North American Melolonthinae by the hind tarsal claws, which are entire instead of being either cleft or toothed. The genitalia are also specifically characteristic.

The beetles were present in 1942 from June 4 until July 22. They are crepuscular, leaving the soil to fly just as the sun sets, (8:45 Eastern War Time) and continuing in flight for about 35 minutes. During this brief period on the wing they fly in large numbers about trees and even telephone poles. Passers-by often mistake them for swarms of bees because of the similarity in size, actions, and wing tone. In general the bulk of the flight occurs from 15 to 30 feet in the air. At the close of the brief flight the beetles settle high in the trees to mate, remaining there until sunrise when they return to the soil and burrow in to a depth of about 4 inches.

Adult feeding is insignificant amounting only to minute serrations on a few leaves of the host trees, which include elm, poplar, maple, box elder, pine, and spruce.

Eggs are laid singly in earthen cells. During the summer of 1942 most of them were placed 2 to 6 inches deep in the soil. Freshly deposited eggs averaged .487 mm. in width, and .729 mm. in length. They enlarged gradually so that just prior to hatching their dimensions had increased to 2.30 and 2.75 mm. respectively. During the first three days of incubation the eggs changed from pearly white to dull gray in color. The duration of incubation was 16 to 19 days under field conditions. In the laboratory maximum oviposition by a single female was 49 eggs. The average was 30.

The larvae are approximately 3 mm. in length at hatching. When fully matured they measured 30 to 35 mm. The larvae can be distinguished from those of similar North American Melolonthinae by the anal opening, which is Y-shaped and surrounded by three lobes, instead of consisting of a simple transverse slit.

Seasonal history observations in the field indicate a first stadium of 35 days, a second stadium of 16 days, and a third of eight months, the latter including the overwintering period.

The larvae have been found feeding on the roots of blue grass, bent grass, orchard grass, red top, timothy, white clover, red clover, alfalfa, oats, corn, dandelion, gladiolus, hardy chrysanthemums, milkweed, goldenrod, strawberries, black spruce, and Douglas fir. Marked preference is shown for the grasses and a lesser preference for chrysanthemums and strawberries. In an old alfalfa field in the infested area the grass was completely killed but the alfalfa left apparently uninjured. In the insectary third instar larvae collected early in the spring were successfully reared through to the pupal stage on roots of a number of legumes and grasses, on germinated wheat or oats, and on pieces of potato. Younger larvae apparently need fine fibrous roots for normal growth.

In general pupation occurred 4 to 8 inches below the surface following a short prepupal period. The pupae are 17 mm. to 19 mm. long, and superficially similar to *Phyllophaga* pupae. The pupal period had a duration of approximately 14 days under field conditions.

The European chafer overwinters as a third stage larva just under the frost line. Hibernating larvae followed the frost to the surface closely, and were at the 2-inch level by the third week of March in 1942. During the past season overwintered larvae began going down for pupation on May 13. Pupation, which occurs at the 8-inch level, began on May 20, and was complete by June 4. Beetles began flying on June 9 and large daily flights continued until July 20. Eggs were found June 20, first stage larvae July 6, second stage larvae August 11, and third stage larvae August 27. Gradual downward movement in the fall began during the first week in November.—1-2-43.

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An Exudation Associated with the Feeding Location of the California Red Scale

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After a California red scale, *Aonidiella aurantii* (Mask.), has been removed from a lemon fruit, a droplet of fluid frequently appears where the scale was feeding. The adult female scale leaves a larger droplet than the immature scale. The fluid may sometimes be seen with a microscope within a few hours after the removal of the insect, but usually it is not readily seen with the unaided eye for several days.

Upon close examination it may be seen that the exudation comes up through the broken-off rostralis in the lemon (Yust 1941). When the droplet is beginning to form and is transparent, it may be ob-

FIG. 1.—Typical appearance of the exudate on lemon fruit.

served on the top of the broken rostralis. As its size increases the fluid runs down onto the lemon fruit. The fluid is sticky, has a sweet taste, and turns brown after it is exposed to the air for a time. Occasionally droplets of this fluid are produced at the feeding site of living scales and may partially or completely cover these insects.

The exudation has been observed to come not only from citrus fruits, but also from squash and citron melon, where red scales were located. Droplets of this exudation are shown on a lemon fruit in figure 1. This substance undoubtedly is the food of the California red scale.

Analysis of this exudation showed it to be practically pure sucrose. Tests of three samples collected from a large number of lemons all confirmed the presence of sucrose. Tests for glycogen and reducing sugars were negative. When a solution of the exudation was hydrolyzed with dilute hydrochloric acid and neutralized with dilute sodium hydroxide, the Fehling's solution test showed the presence of reducing sugars. The exudate formed an osazone in 30 minutes. The melting point of the osazone was 202–204° C., which is the same as that of the glucose or fructose osazone formed on hydrolysis of sucrose. The osazone was found to have the same crystal structure as the glucose osazone. The exudate contained no natural yeast, and to produce fermentation it was necessary to inoculate the material with yeast. Because of the limited quantity of the material the optical rotation was not determined.

Fungus grows readily in this exudation under humid conditions, and when the exudation covers a scale the fungus appears to be growing on the scale body itself.—1-11-43.

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Surface Area of Persian Walnuts

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During the summer of 1938, an investigation was carried out at the Citrus Experiment Station on the control of the walnut husk fly. In connection with this investigation, a large number of analyses were made on the initial deposit and weathering of various insecticides. Since all comparisons were made on a deposit per unit-area basis, it was necessary to determine the total surface area of each sample and to devise a sufficiently accurate method for making such deliminations.

The shape of a green, unhusked persian walnut is best characterized as a general ellipsoid with three unequal axes. While it is possible to set up a mathematical expression to determine the area of such a conoid, the process of calculation of the areas is too long and complicated to justify its use. Instead the assumption is made that the surface area can be adequately represented by an ellipsoid of revolution, in which the two minor axes are equal. Three measurements are made on each nut, length, width and thickness. An average length and diameter is calculated for each sample and the average area per nut determined by:

$$A = 2\pi\left(b^2 + \frac{ab}{e}\,\mathrm{Sin}^{-1}\,e\right)$$

where a is $1/2N\Sigma$ (length), b is $1/4N\Sigma$ (width+thickness), N is the number of nuts in the sample and e, the eccentricity, is calculated by:

$$e = \left(1 - \frac{a^2}{b^2}\right)^{1/2}$$

Multiplying A by N will give the total area.

For a sample of 50 nuts, this method requires 150 measurements and an involved calculation and is altogether unsuitable for use in routine analyses. It was therefore necessary to shorten it.

Table 1.—Correlation and regression between area and volume.

	IMMATURE NUTS	MATURE NUTS	BOTH STAGES
Number of samples	36	22	58
Range of areas sq. cm.	28–42	48–66	28–66
Regression coefficient area/volume	1.23	0.894	1.02
Intercept sq. cm.	8.4	18.4	13
Standard error of estimate sq. cm.	0.62	0.57	0.83
Coefficient of correlation "r"	0.998	0.990	0.998
Probability of r being due to chance	3×10^{-8}	3×10^{-6}	2×10^{-10}

Fourteen samples of 50 nuts each, representing a random distribution, were selected from several picked in early June from the Chino-Puente area. The nuts were all medium sized and had not yet attained their full growth. Twelve of these were divided at random into smaller samples of from 10 to 18 nuts each so that the variation could more adequately be studied. The nuts were first measured and then the volume of the sample determined. This may be done by placing the nuts in a marked gallon container, filling to the mark from another container holding exactly a gallon and measuring the excess in a liter-graduated cylinder. As the nuts have a tendency to float, it will be necessary to hold them under the surface with a piece of wire screen. The average area per nut was calculated by the method already described and correlated with the average volume. This was repeated later in the season for mature nuts.

The correlations were very highly significant and the error of estimating area from volume was well within the usual limit of error for most field or laboratory experiments. During the last four years this shortened method has been used continuously with good success. Since only a small range was covered in comparison with the total and since a very good fit was obtained with linear correlation, no attempt was made to use curvilinear methods.

The area of the immature nuts is calculated by the equation, $A = 1.23V + 8.4$, A and V being in square and cubic centimeters respectively. The others are similarly calculated by substituting in the correct values for the regression coefficient and intercept. Since these values may change with locality and variety, they should be determined before using this method.—1-7-42.

Delayed Emergence of *Buprestis aurulenta* from Structural Timbers

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The golden buprestid, *Buprestis aurulenta* Linn., is a fairly common species in the coniferous forests of Western North America where it breeds in lightning-struck, fire-scorched, or dying trees as well as in recently felled logs and stumps. The preferred host appears to be Douglas fir (*Pseudotsuga taxifolia*) but practically all of the species of pine occurring within its range are also attacked. It occasionally breeds in spruce (*Picea* spp.) and Helfer (1941) also lists fir (*Abies grandis*) and western red cedar. The latter host, if based on an authentic record, is probably exceptional. The beetles normally fly from April to September. The larvae usually require from one to three years to complete their development and readily mine heartwood as well as sapwood. Pupation takes place in late summer or fall. Transformation occurs in the fall and the adult overwinters in the pupal cell, emerging during the following spring.

Buprestis aurulenta, aside from the fact that it is one of the most beautiful of our North American species, has attracted considerable attention in recent years because of its habit of unexpectedly emerging from structural wood long after the wood is finished and put in place. Huguenin (1915) was possibly the first to call attention to this habit. He recorded the emergence of a beetle from the doorsill of a bathroom in a home in California. The house was 26 years old and the doorsill was made of pine which had never been replaced having been twice painted and varnished. Huguenin asked, but did not attempt to answer, the question as to whether the infestation occurred prior to the building of the house or whether a stray beetle entered the house and oviposited on the door. Chamberlin (1924) has noted the emergence of a specimen from a 9 year old, varnished, stairway handrail in Oregon. Spencer (1930) records five similar cases in British Columbia, involving the floors of a church and a house, a veranda, a door, and an inside house wall an inch from the ceiling and 29 inches from the outside wall. The ages of the structures varied from 12 to 20 years. In the past few years several cases of this kind have come to the attention of the writer. Since 1937 these have been carefully noted and are recorded in table 1. These represent twelve cases, all from California, in structures varying in age from 10 to 26 years.

If we turn to a consideration of the question cited above which was posed by Huguenin, a number of interesting points must be weighed. First of all, most *Buprestis* oviposit in cracks and crevices of the bark and the larvae require a bark covering during their early larval development. However, Spencer (1930) records what may have been *B. aurulenta* going through oviposition movements in cracks in the floor of a veranda of a new building, and similar behavior of *B. langii* Mann. on a flag pole. Doane *et al.* (1936) stated that the species attacks sawed lumber and is one of the very few species which do not absolutely require bark in which to oviposit. Furniss (1938) records *B. langii* Mann. emerging in numbers from a large Douglas fir timber in use on a dock for 11 years. Spencer (1930) suggests that "these beetles do not necessarily escape several hazards to pass through a greatly protracted larval and pupal period amounting in one case to 20 years *but* are capable of developing from eggs laid in cracks in prepared lumber, even of heartwood, without feeding first on bark, bast, cambium, or sapwood." Furniss (1938) apparently agrees, stating that the emergence of *B. aurulenta* and *B. langii* from Douglas fir flooring and siding does not necessarily indicate that they have been in the building since erected but that in regions where they are native they may oviposit and rear broods in lumber after it has become part of a building.

While the writer is willing to grant the possibility, or even probability, that *Buprestis aurulenta* will oviposit on new lumber, there are several considerations that argue against this explanation in the above cases (a possible exception is the veranda cited by Spencer). In the first place, this species, like its relatives, is a sun-lover, flying about, mating, and ovipositing in the brilliant sunshine of midday. It avoids the shade and therefore the likelihood of its flying into a building and ovipositing on the floors, walls, etc. impresses me as very unlikely. Secondly, many of the infestations appeared in protected places, even within the house, decreasing the probability that oviposition was direct. Thus in table 1, the last two cases cited involve a linoleum covered floor and shelving inside a kitchen cabinet. Thirdly, the adult beetles are very conspicuous, being nearly an inch long, brilliant green with a golden margin. It is not likely that they would remain long in an occupied house without being discovered. Finally, the fact that Franz (1936) records *B. aurulenta*, an American species, as emerging in Frankfurt from a dresser 13 years after its manufacture partially from wood of American origin, would seem to be ample evidence that the infestation must have been present in the unfinished wood.

Table 1.—*Buprestis aurulenta* emergence records reported at Berkeley during five year period from 1937 through 1942.

DATE	LOCALITY	INFESTED MATERIALS	AGE OF MATERIALS
11/2/37	San Francisco	Pine flooring, attic	16 years
1/6/38	Oakland	Pine or Douglas fir studs, basement	Unknown (not new)
1/9/42	Los Angeles	Pine flooring	22 years
10/17/38	Palo Alto	Pine floor joists	9–12 years
10/9/39	Oakland	Pine floor joists	13 years
10/21/39	Fresno	Pine flooring, basement	11 years
5/29/40	Berkeley	Pine floor joists	26 years
11/2/40	Sausalito	Pine studs, attic	10 + years
10/10/41	Fresno	Pine floor joists	Unknown
12/17/41	Oakland	Pine flooring	18 years
1/21/42	Mill Valley	Pine flooring (linoleum covered)	23 years
9/7/42	Berkeley	Pine shelving (inside kitchen cabinet)	19 years

Based upon our present knowledge of the problem it would seem that the following conclusions may be drawn: (1) *Buprestis aurulenta* frequently emerges from prepared timbers after they are in place in a structure; (2) there is some evidence to indicate that *B. aurulenta* may oviposit on green lumber and exposed timbers in the open; (3) there is no good evidence to indicate that the species ever flies into a building and oviposits on finished wood in place in a structure; (4) the emergence of a specimen in Germany from 13 year old furniture made partly from wood imported from America proves beyond a reasonable doubt that the species is capable of a prolonged existence in cured wood.—1-19-43.

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Rearing Southern Corn Rootworms on Seedling Corn Plants

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During the progress of studies relative to the resistance of corn to the southern corn rootworm, *Diabrotica duodecimpunctata* (F.), it became important to know whether feeding on different inbred lines of corn had any effect upon the development of the larvae of the insect.

Artificial field infestation failed, so we resorted to a strictly controlled test in the laboratory. The senior author first tried the various techniques of Arant (1929), Isely (1929) and Sweetman (1926). These failed for our purpose at the point of maintaining the growing larvae on individual corn plants. Because of this fact, the technique described here was developed. It is a result of our knowledge of the means used by certain plant pathologists to make disease tests.

OVIPOSITION CAGES.—Oviposition cages consisted of 100×37 mm. shell vials stoppered with cotton and with moist blotting paper on the bottom of the vial. Adults in these cages were kept supplied with fresh soybean leaves which were replaced as necessary. A mixture of varieties of beans was used to furnish these leaves.

HATCHING CHAMBERS.—Eggs were collected daily from the oviposition cages with a camels hair brush and placed in hatching chambers designed more or less after Searls (1928). These consisted of chambers made from the same vials as used above, but cut down to about 30 mm. deep. In the bottom of these

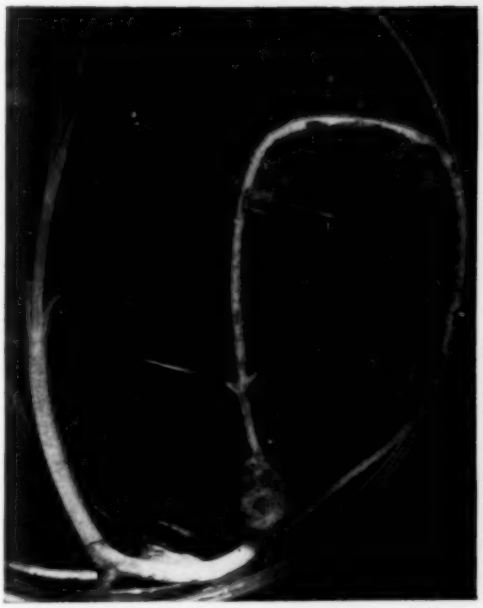

FIG. 1.—Corn seedling growing in petri dish. Shows feeding scars and portion of larva of southern corn rootworm (head embedded in plant at lower left hand corner).

was placed a mixture of 92 per cent plaster paris and 8 per cent bentonite. The plaster paris-bentonite mixture was mixed with water, placed in a pan and the glass tubes sunk into it. The bentonite prevented undue swelling of the material and prevented breakage of the tubes.

About 25 to 30 eggs were placed in each one of these tubes and they were kept in moist sand in a convenient pan.

FEEDING CAGES.—When the larvae hatched, they were removed with a camels hair brush to seedling plants growing on agar-agar in a petri dish and kept there until the prepupae appeared. Only larvae which had hatched during the previous 24 hours were used. For this purpose petri dishes were sterilized in an electric oven for two hours at 200° C. The plates were prepared by dissolving one gram of agar-agar in 100 c.c. of distilled water, autoclaving at 15 pounds pressure for one-half hour, and pouring about one-quarter inch of the solution into the sterile petri dishes. After the solution had hardened, two kernels of corn were planted in each. The seed coats of the corn had been previously sterilized by immersing them for 15 minutes in a freshly prepared saturated solution of calcium hypochlorite. Two kernels were planted so as to assure the development of one plant in each dish. The use of the calcium hypochlorite was suggested by Dr. Neil Stevens, Professor of Botany, University of Illinois, after we had failed with an attempt to sterilize by use of an 0.2 per cent solution of mercuric chloride in 50 per cent alcohol. The calcium hypochlorite left no poisonous residue on the kernels.

This procedure was very satisfactory. Larvae lived for 2 to 3 weeks on growing seedlings in such cages.

Checks were run with only agar-agar in the plates. In all cases, larvae died within 48 hours in these check plates.

PUPAL CAGES.—The prepupae were removed to metal salve boxes filled with a loam-sand mixture of such proportions that the soil did not become muddy or bake hard. Holes were punched in the bottoms of the boxes and they were placed on moist sand in a pan. The specimens were left there until adults emerged.

All stages of this material were kept in a temperature-humidity controlled chamber at 29–30° C. temperature and 65–70 per cent relative humidity.

Since our eggs hatched in 7 to 8 days and corn was sprouted sufficiently to be infested after a period of 3 to 4 days, we were able at all times to regulate the number of seedlings to accommodate hatching larvae.

A continuous series of tests were kept running from June 20 to August 29, 1940. Daily records were made on all material in the tests. In all, six series were run with each of 10 inbred lines and from two to 10 dishes of each were in use at any one time. Useable data were gathered from 649 larvae, 147 of which became prepupae, 94 pupae and 56 adults. Because we were testing inbred lines of corn, some of the larvae failed to develop on certain lines to, or beyond the prepupal stage, which was part of the reason for the great reduction in the numbers maturing.

The authors of this paper do not claim a new and startling method of growing corn—merely an adaptation to entomological problems. We offer this as a convenient method of rearing these larvae where it is essential that the food be restricted to limited kinds.—12-3-42.

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Orchard Dusting Experiments with Natural Cryolite for Codling Moth[1]

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Realizing that there would be a labor shortage, perhaps for some years to come, it was decided that a dusting program was in order. During the season of 1942, apple orchards were dusted; some with *Kryocide* and sulphur, and others with lead arsenate and sulphur, the latter dust being used as the conventional yardstick. *Kryocide* is the trade name of natural cryolite (sodium fluoaluminate), which, as now offered, is milled to a fineness of 5 microns. In previous years (Dobroscky 1937), *Kryocide* had been tested as an orchard spray with satisfactory results, so this year it was used for the first time as a dust.

The delayed dormant and the pre-pink sprays were, as usual, made up of lead arsenate and lime sulphur. From then on, during May, June and July, the orchards were dusted for the control of both insects and diseases. Since the toxicity of cryolite is destroyed by lime (Dobroscky 1935), dusting sulphur alone was used as the diluent.

Two blocks of McIntosh trees, so widely separated that there could be no possibility of the dust drifting from one to the other, were chosen for the experiment. One block, consisting of 45 trees about 15 years old, was dusted with cryolite and sulphur; another block of equal number, was dusted with lead arsenate and sulphur. The dust mixtures were made up at the rate of 80 per cent sulphur and 20 per cent of the two insecticides, respectively.

ORCHARD DUSTING EXPERIMENTS.—The dusts were applied as needed at the following rates: three applications in May, three in June, and two in July. Each tree was dusted from two sides and received about a pound and a half of the dust per application. The time for dusting was generally from 5 to 9 A.M. as at that time the wind was quite still, and in addition, there was a fine coating of dew on the trees. The applications were timed especially for codling moth control and apple scab. Dusting was found to be extremely adaptable to the control of the scab fungus. Because it is possible to dust in a rainy period, and because it takes such a short time to cover an orchard with dust, it is possible to time and execute the dusting applications very promptly and speedily. In 3 hours, it was possible to dust as many trees as it normally took 3 days to spray. Such difficult problems as water shortage; the time it takes to fill a spray tank; the weight of the spray rig causing traction trouble on wet ground or on steep hillsides; innumerable mechanical troubles with the spray rig; all such problems were eliminated by the use of a duster.

Table 1.—Data on codling moth and apple scab from samples of 100 apples taken from trees dusted with lead arsenate and *Kryocide*.

SAMPLE TREE NO.	CODLING MOTH INJURIES	SCAB
Lead Arsenate and Sulphur Dust		
1–1	8	1
1–2	13	
1–3	28	2
2–4	28	
2–5	20	
2–6	15	1
3–5	8	2
3–6	13	1
3–7	7	
4–6	6	1
	14.6	.8
Kryocide and Sulphur Dust		
1–8	13	1
1–9	9	1
2–2	10	2
3–1	5	4
3–2	6	4
3–3	2	4
3–4	6	2
3–5	7	3
3–6	3	3
3–7	6	4
	6.7	2.8

[1] Eastern Branch Program, New York, November, 1942.

During May, which is generally a rainy month, the dusts were applied for the control of the scab fungus, during June and July for the control of the first and second-brood codling moth.

At harvest time, a sample of 100 apples was picked at random from the bottom and top of each tree. Samples were taken from 10 trees in each of the two blocks. Data obtained from these are shown in the accompanying table. The data show that *Kryocide* gave much better control of codling moth than did lead arsenate. The average number of stings and entries in the lead arsenate samples was 14.6 per cent; in the Kryocide samples the number was 6.7 per cent. The control of apple scab was also very satisfactory, in spite of the fact that it was a rather wet growing season. From the entomologist's point of view these results may not look too good, but from the commercial and economic point of view they are quite acceptable. No injury to fruit or foliage has been observed from the use of natural cryolite.

The fact that the lead arsenate block did not show up as well as the *Kryocide* block may have been due, in part, to the fact that these trees were nearer to the packing shed and other farm buildings, which have some relation to the incidence of codling moth. Next year it is planned to reverse the treatment of these two blocks of trees.—12-12-42.

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The Yam Bean, *Pachyrrhizus erosus* Urban, as a Possible Insecticide

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The yam bean is widely but not intensively grown throughout the tropical regions of the world for its tuber-like roots which are used for food. In the western hemisphere it is grown in Mexico where it is called *jicama*, in Brazil where it is called *jacatupe*, and in other South and Central American countries and the West Indian Islands where it may be called yam bean or *sincamas*. The seeds on which the following data are based were sent from Kwangsi Province in China. At least three species in several varieties exist, *Pachyrrhizus erosus*, *P. tuberosus* and *P. palmatilobus*, being the best recognized forms. An examination of the nomenclature and the taxonomy of the genus is being undertaken by the botany department of Cornell University because of the possible commercial importance of the plant.

The seeds of this plant have long been used as an insecticide and a fish poison in various tropical countries. Boorsma (1910) discussed the toxicity of seeds, leaves and roots of the plant to fish, dogs and other vertebrates. He called the toxic principle of the plant pachyrrhizid because of the similarity of the relationship with *Derris* and its toxic principle which was then called derrid. In China Liu & Hsu (1941) reported the ground seeds to have high efficiency used as an insecticidal spray against the striped flea beetle, *Phyllotreta vittata* F., the green peach aphid, *Myzus persicae* Sulz., and the sugarcane wooly aphid, *Oregma lanigera* Zehntner, in Kwangsi province. It was used at 4 lbs. per 100 gallons, approximately the same rate that would be recommended for the use of 4–5 per cent derris root for these insects. The plant was shown qualitatively to contain rotenone (Hwang 1941).

In our own laboratory the sample was found to contain only a trace of rotenone by the Goodhue modification of the Gross & Smith colorimetric method. Extractions for eight hours in Soxhlet apparatus gave the following per cent total extractives: alcohol, 27.8 per cent; acetone, 22.8 per cent; chloroform 18.6 per cent; petroleum ether (B.P. 60–70° C. , 18.6 per cent; and carbon tetrachloride, 19.4 per cent.

In toxicity tests 4 per cent cube root was used as a standard material for purpose of comparison. Tables 1, 2, and 3 give the essential data from these tests.

Table 1.—Toxicity of water suspensions of yam bean and cube to *Aphis rumicis* L. One hundred aphids (mature, apterous, agamic females) used in each test. Aphids sprayed on flannel and transferred to unsprayed nasturtium leaves. Counts made after 24 hours. Mortality corrected for that in the check.

PLANT USED	g./100 cc.	PER CENT MORTALITY
Yam bean	1.5	99
" "	1.0	93
" "	0.5	80
" "	0.2	48
" "	0.1	24
" "	0.05	9
" "	0.02	14
" "	0.01	13
Cube	0.5	100
"	0.2	95
"	0.1	97
"	0.05	92
"	0.02	64
"	0.01	38
"	0.005	18
"	0.002	5

In addition to these insects, tests were made with water suspensions containing 1 g./100 cc. of ground seeds and of 4 per cent cube root against newly hatched codling moth larvae. Apples were sprayed, allowed to dry and ten eggs in the blackhead stage placed on each apple. Seven days later the fruits were examined for stings. One hundred and twenty eggs (12 apples) were used in each test. Forty per cent of the larvae were able to enter fruit sprayed with yam beans, but only 6 per cent entered the cube sprayed fruit. Lead arsenate at the rate of 3 pounds per 100 gallons also permitted 40 per cent entries.

Although these preliminary experiments are intended to indicate the possible importance of the plant as a source of insecticidal material, several tentative conclusions might be drawn from them. Because of the difference in toxicity between yam bean and cube in experiments with the imported cabbage worm and the codling moth, it is probable that the toxicity of yam bean is not primarily rote-

[1] Eastern Branch Program, New York, November, 1942.

Table 2.—Toxicity of yam bean and cube to several insects when used as a stomach poison. Insects placed on dusted foliage and mortality noted after 48 hours.

PLANT	SPECIES OF INSECT	NO. INSECTS	PER CENT MORTALITY
Yam bean	*Epilachna varivestis* Muls. 1st instar larvae	69	100
Yam bean	*Archips cerasivorana* Fitch mature larvae	25	28
Yam bean	*Alsophila pometaria* (Harr.) mature larvae	25	4
Cube root	*Alsophila pometaria* (Harr.) mature larvae	25	4

none. The fact that the plant was more toxic to the silkworm than cube, but was shown by chemical analysis to have only a fraction of a per cent of rotenone present also supports this theory.

Several factors should be considered when examining these data. The seeds were collected in the fall of 1940, but insecticidal tests were made between the fall of 1941 and 1942 The fact that the ground seeds were from one to two years old at the time of testing may have altered their initial toxicity. Only one sample of seeds has been available for testing. When it is considered that jungle-collected cube may run from less than 1 per cent rotenone to around 7 per cent, with corresponding variations in toxicity, it becomes apparent that subsequent collections of yam bean seed may be expected to exhibit much higher or lower toxicity.

Experiments on the toxicity of yam bean seed is of particular interest at the present time because of the possibility it offers as an annual crop which may be harvested from 4 to 6 months after planting. With a sufficient supply of seed produced in 1943, the yam bean offers a possible partial substitute for rotenone insecticides during the season of 1944. A recent personal communication from the College of Agriculture, National Sun Yat Sen University in Ping-shek, Kwangtung province, China, advises that yam bean seed was widely used during the summer of 1942 in western China in the control of several insect pests of staple food crops[1]. —1-11-43.

Table 3.—Toxicity of extracts of cube and yam bean to the silkworm, *Bombyx mori* L. and to the imported cabbage worm, *Pieris rapae* L. All extracts were used at a concentration equivalent to one gram of dry powder per 100 c.c of water. Leaves were dipped in emulsions of extract in water and allowed to dry before test insects were placed on them to feed. Counts made after 96 hours.

INSECT	PLANT	EXTRACTOR	NO. INSECTS	PER CENT MORTALITY
B. mori	Yam bean	Carbon tetrachloride	50	90
		Alcohol	125	97
		Acetone	50	100
		Chloroform	50	92
		Petroleum ether	50	100
	Cube root	Carbon tetrachloride	25	76
		Alcohol	50	98
		Chloroform	50	74
		Petroleum ether	25	52
A. rapae	Yam bean	Alcohol	25	20
		Petroleum ether	25	24
	Cube root	Alcohol	25	100

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[1] Since the above paper was read considerable additional data have been obtained. Examination of the insecticidal properties of 12 samples from the western hemisphere showed consistently high kills of Mexican bean beetle larvae in laboratory tests with 20 per cent of the ground bean in talc. Total extracts averaged around 28 per cent, about 90 per cent of which was oil, the remainder being resinous in nature. When the fractions were tested in sprays against aphids, the resin fraction was found to contain most of the toxicity. Detailed chemical and toxicological data will be published in an early number of this *Journal*.

Influence of Inbreeding on the Susceptibility of the California Red Scale to HCN

HAROLD R. YUST, HOWARD D. NELSON, and R. L. BUSBEY, *U. S. D. A. Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

In the study of the California red scale, *Aonidiella aurantii* Mask., the question has frequently arisen whether continued inbreeding, as it occurs when a segregated stock is maintained in the laboratory, decreases the vitality of the insects and thereby increases their susceptibility to hydrocyanic acid.

To determine the influence of inbreeding, a stock of resistant scales was divided into two groups (A and B) in 1937. In 1941, after the two groups had been segregated for more than 4 years (18 generations), a third group (AB) was formed by infesting lemon fruits with about equal number of scales of groups A and B. At the same time in 1937 a stock of the nonresistant strain of red scales was likewise divided into two groups (A and B), and after over 4 years a third group (AB) of nonresistant scales was formed. In the third group (AB) of each strain the males and females in groups A and B crossed. The different groups of scales were reared in isolated compartments under similar conditions. If inbreeding influences susceptibility to hydrocyanic acid, it was thought likely that the mortality of the F_1 generation of the third group would differ from that of the two segregated groups of the same strain in fumigation treatments.

In 1941, lemon fruits were infested simultaneously with first-generation insects of the AB groups of resistant and nonresistant strains and with scales in the nineteenth generation of the A and B groups of resistant and nonresistant strains, and the susceptibility of the six groups to hydrocyanic acid was compared. The scales were reared at a temperature

of 77° F. and a relative humidity of 65 per cent and were fumigated at the same temperature. The methods of rearing and treatment were the same as those described by Yust *et al.* (1942). Scales in the second molt 21 days old and mature females 35 and 36 days old were fumigated. In the second molt the resistant scales were fumigated with a concentration of 1.4 mg. of hydrocyanic acid per liter and the nonresistant scales with 0.34 mg. per liter. The resistant mature female scales were fumigated with a concentration of 0.9 mg. per liter and the nonresistant mature females with 0.18 mg. per liter. Fumigations of scales in the second molt were duplicated on 2 days and those of mature females were made on 1 day. The mortality figures for each stock in the second molt and for each nonresistant group of mature females are based on 1200 insects and those for each resistant group of mature females are based on 600 insects. The results of these tests are given in table 1.

Table 1.—Comparative resistance of segregated and of mixed groups of resistant and nonresistant strains of the California red scale to fumigation with hydrocyanic acid gas.

	Mortality, Per Cent			
	Second Molt		Mature Female	
Stock	Resistant	Non-resistant	Resistant	Non-resistant
A	89.2	93.8	96.7	94.8
B	88.7	95.6	97.3	93.2
AB	89.7	95.3	97.7	94.2

The mortalities of the three groups of the same strain and stage were about the same in all cases, an indication that the inbreeding resulting from the procedure followed did not influence the susceptibility to hydrocyanic acid. The similarity between kills of the A and B stocks of the same strain suggested that there was very little, if any, mixing of the nonresistant and resistant strains over the segregation period of over 4 years. The rearing procedure was such that equal contamination of the two stocks by insects of other strains would be very improbable.—10-21-42.

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Three New Pests Invade Utah

George F. Knowlton, *Utah Agricultural Experiment Station, Logan*

An infestation of the brown banded roach, *Supella supellectilium* (Serv.) (det. Dr. H. K. Towns), was found in a home at Logan, January 8, 1942. The roaches were abundant in the kitchen, a few invading other nearby rooms.

On May 2, 1942, F. C. Harmston collected specimens of *Ptinus latro* F. (det. W. S. Fisher) which were infesting bacon and prepared wheat cereal in a grocery store at Salt Lake City. Mr. C. F. W. Muesebeck mentioned that this was "a European species of Ptinidae which, so far as we know, has not been previously recorded from the United States. It is pointed out by Mr. Fisher, however, that the insect has been reported as occurring in Canada. Probably it is another ptinid which is becoming cosmopolitan."

During the winter of 1941–42, a shipment of lima bean seed from outside the state was received in Salt Lake City. On inspection, this proved to be heavily infested with weevils. The teneral individuals which were sent to the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, were identified by H. S. Barber as probably *Zabrotes subfasciatus* Boh. Prompt fumigation doubtless stopped the escape of this pest.

This is the first time the writer has learned of the occurrence of any of these three species within the State of Utah.—3-22-43.

Ptinus tectus[1] Damaging Furs in Alaska

Melville H. Hatch, *University of Washington*

Specimens of *Ptinus tectus* Boield. taken in December 1922 were brought in recently by Mr. N. G. Hanson, a storekeeper and trader located at Platinum, Alaska, Goodnews Bay on Bering Sea, at about 59° north latitude. Since 1941 the beetles have done a couple of hundred dollars worth of damage both to raws furs and to fur garments. A fox skin looked as though perforated by a shot gun, the tail had been eaten off the skin of a white ermine, and much fur had been removed from an otter skin. Mr. Hanson said he had seen specimens of the beetle reported as doing similar damage at Quinhagak, 75 miles north of Platinum, and had had them reported from Bothel, 110 miles north. Moreover, he said that this was the only insect of any sort he had so far encountered infesting his stores.—4-16-43.

[1] Coleoptera: Ptinidae

Sodium Fluosilicate to Control Poultry Lice

Henry E. Parish, *U. S. Department of Agriculture Agricultural Research Administration Bureau of Entomology and Plant Quarantine*

In an attempt to find a suitable substitute for sodium fluoride, which is now an essential defense material, 1,830 chickens were treated for the control of poultry lice during the period January 28 to November 21, 1942.

With sodium fluoride as a check, eight laboratory and eight field tests were conducted using sodium fluosilicate of 35- and 98-per cent[1] purity. Very encouraging results were recorded when these materials were used as dusts and dips in laboratory tests. The dusting of chickens for the control of poultry lice was performed by the "pinch method," and in dipping tests two concentrations were used—½ ounce and 1 ounce of chemical per gallon of tepid water. In some of the tests a near-neutral soap was added at the rate of 1 ounce per gallon of water. This resulted in a more thorough and speedy wet-

[1] Samples obtained from Henry Sundheimer, Inc.

ting of the test animals but had no apparent effect on the efficacy of the test material.

One field test was conducted in which the "pinch method" of dusting was used, the results of which were not so satisfactory as those recorded in laboratory studies. This test involved 166 birds, and 28 days after treatment 91 live lice were found when the entire flock was examined. At the time of treatment this flock was in the process of molting and many of the feathers present had very few barbules on them.

In all field tests, observations to determine kill of lice and effect of treatment on the chickens were made at 7-day intervals over a period of 21 to 35 days. Observations on laboratory-treated animals were made more often over a period of 21 to 27 days. The chickens treated ranged in age from 2 months to adult. No harmful effects were noted from either of the test materials.

Seven grown and two 1-month-old peafowls were also dipped in a solution containing 1 ounce of 35 per cent pure sodium fluosilicate which resulted in complete destruction of a heavy infestation of *Goniodes pavonis* (L.) with no apparent ill effect on the hosts.

Dips containing 1 ounce of sodium fluoride, sodium fluosilicate 35 per cent pure, or sodium fluosilicate 98 per cent pure per gallon of dip gave 100 per cent control of lice on 385, 361, and 793 birds respectively. The same results were obtained when 88 chickens were dipped in 0.5 ounce of sodium fluosilicate (98 per cent pure) per gallon.—2-19-43.

Airplane Runways Damaged by Ants

W. M. GORDON, *Naval Air Station, Corpus Christi, Texas*

The Red Harvester Ant *Pogonomyrmex barbatus* var. *molefacieus* (Buckley) has caused some damage to airplane runways at several of the Auxiliary Naval Air Stations near Corpus Christi, Texas.

This species is common in this area and their circular, flat, bare nests may be readily seen in the grain and cotton fields and pastures. The runways have in many cases been built over these nests, and as many as 25 or 30 have been discovered on a runway measuring 2500 feet long by 300 feet wide. When aircraft taxi over these nests, which are a network of tunnels and chambers under ground, the weakened areas give way and depressions form on the runway. These depressions are 2 to 4 inches deep and 18 to 24 inches in diameter. The nests are frequently found in the center of a runway opening on the surface. The fact that this ant is not a mound-building species makes the job of locating the nests a difficult one, and what soil is brought to the surface of the runway is nearly always blown away by the plane. The runways which are constructed of a 4-inch caliche base and a 1-inch "hot topping" of hot tar and gravel, are unable to stop these determined insects from making their exit.

Control consisted of driving a pole (size of broom stick) through the crust until the point was among the galleries of the nest. This was easily determined by the ease with which the point passed through the cavities. The pole is removed and 4 to 6 ounces of carbon disulphide is poured into the hole; or granulated calcium cyanide is pumped into the hole by means of a foot pump. The opening is then sealed with a piece of sod.

Nearly 100 per cent control has resulted from the use of either of these methods on the first application and never more than two applications were needed to destroy a nest completely.—5-14-43.

Accidental Transportation of Mosquitoes by Automobile[1]

DON E. EYLES, *Associate Biologist, U.S.P.H.S., Memphis, Tenn.*

Prior to leaving Reelfoot Lake for Memphis, Tennessee, on August 29, 1942, a United States Public Health Service passenger vehicle was parked overnight on the lawn of the Reelfoot Lake Biological Station with the baggage compartment in the rear of the vehicle open.

It was noted on leaving Reelfoot at about noon the next day that there were about 200 mosquitoes[2] in the compartment. The weather was normal for the time of year, and upon arriving at Dyersburg, Tennessee, about 40 miles south of Reelfoot Lake, the mosquitoes were still living. Several left the compartment when it was opened.

At Memphis, 120 miles south of Reelfoot Lake, after about five hours on the highway, the mosquitoes were still alive and some left the baggage compartment when luggage was removed. Probably the remainder of the mosquitoes left the compartment at nightfall as the compartment could not be closed tightly.

It was suggested to the writer by J. A. Le Prince[3] that cases of malaria contracted in localities supposedly free of *Anopheles* might be explained in this manner, as mosquitoes might be introduced in cars of fishermen and other persons from malarious areas. Maximum temperature at Memphis on the day upon which these observations were made was 89° F. (Mean 76° F.; a normal day for the season) and at Union City, Tennessee, near Reelfoot, 90° F. The sky at Memphis was clear.—3-15-43.

[1] From Office of Malaria Investigations, Division of Infectious Diseases, National Institute of Health, U. S. Public Health Service, Memphis, Tennessee.

[2] *Anopheles quadrimaculatus* Say.

[3] Sanitary Engineer Director (Retired), formerly in charge of Malaria Investigations, U. S. Public Health Service.

COMMON NAMES OF INSECTS

The Committee on Common Names of the Association invites submission of additions to the list of common names of insects and suggested changes in common names of insects included in previous lists for consideration by the Committee and by the members of the Association.

RAY HUTSON, *Chairman, East Lansing, Mich.*

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Entomology and the War

WE ARE PRONE in time of emergency to think of the subject matter of our particular science as needing unusual emphasis or treatment. This is due to the stress of immediate demands, and should not confuse our thinking in regard to the ultimate aims and the fundamental processes for their achievement.

It takes at least four years under peace time economy to give a student sufficient training in entomology, basic sciences and humanities so that he can be expected to apply his technical knowledge with a modicum of balance and judgment. It takes several more years to produce a specialist whose judgment on, for example, such matters as taxonomy, may be accepted with reasonable assurance that his dicta may be correct. In entomology with a direct application to our daily economy even the student who has attained the doctorate, unaccompanied by experience in the field, frequently fails to measure up to the requirements of some situations. This is to emphasize the time element in the training for entomological work. Hence, those already trained must meet the intensified demands engendered by war. What are some of the present needs?

1. Control of insect vectors of diseases.
2. Prevention of damage to military materiel.
3. Civilian protection from diseases that may develop as a result of the movement and congregation of large numbers of men in war areas.
4. Protection of crops and animals under war conditions; i.e. shortages and restrictions on insecticides, shortages of equipment, shortage and inexperience of labor, and the demand for increased production.
5. Supervision of inexperienced individuals drafted into work that is unfamiliar due to the demand of the armed forces for some of the profession's best trained young men.

1. Control of insect vectors of diseases: Since in this global war our armed forces are in every corner of the earth, a preknowledge of the insects and diseases that may be encountered by our soldiers, sailors and marines is of primary importances. Successful methods of combatting them are of the utmost importance. Knowledge of what insects and diseases may be present in any combat area is the sum total of the painstaking studies of many investigators and is available to any student. It is the fund of information that is supplied by instructors to the student of medical entomology, but it does not take into consideration the new or unusual contingencies that may arise. To meet these, the fundamental training that requires years of careful preparation in school is essential. To teach a student to think problems through accurately is the most important function of college training. No six weeks intensified training without this background will suffice to give our armed forces the protection that they need. With the fundamental training in entomology such courses serve to orient the officer with respect to known objectives and increase his value.

The variability of the malaria control problem illustrates the need for broad training and accurate knowledge. Over 60 species of anophelines are known to transmit the malaria organisms, but these in all probability do not exhaust the possible vectors. In order to determine the species involved in some isolated place is no small task, but absolutely essential in order that the known ecology may be properly associated with the control effort. If and when a new species is suspected, the ingenuity, the industry and the ability to think clearly determines the success of the entomologist in learning the ecology and adjusting the control to the ecological factors. Anopheline zootrophy plays an important part in many places where troops are likely to be quartered.

The presence of large animals may give almost perfect protection from some species and none at all from others.

Ticks, responsible for many relapsing fevers, will test the ecological skill of our entomological forces in far places. Likewise, the American soldier will find it necessary to adopt the precautions devised by entomologists to meet the threat of a host of insect vectors of which he has had no previous experience.

2. Prevention of damage to military materiel: to maintain our armed forces calls for the greatest diversity of materials, much of which is subject to insect attack. The protection of stored foods from pests, its protection during and after preparation from contaminating insects, such as roaches and flies, mothproofing clothes and blankets, impregnation of cloth to control lice, treatment of timber and finished wood products to prevent damage from borers and termite control in finished buildings call for a broad knowledge of entomology and most efficient and economical control. As an example of the diversity of the problems soil infesting termites have caused serious damage to air field runways, creating dangerous hazards to planes taking off or returning.

3. Civilian protection from diseases: The concentration of men in army and navy installations brings problems of great moment to the civilian population. This is especially true of such an insect-borne disease as malaria. Those responsible for the public health need and are getting the active help of entomologists in the prevention of outbreaks of insect-borne diseases that may start from the juxtaposition of the proper mosquito vector and the carriers that may be gathered in any cantonment from far and wide. This is especially true in those areas where imported labor is used in construction activities. The armed forces have adequate provision for the protection of their own personnel, but when civilian and military forces are mixed during construction the hazard is multiplied, particularly in the surrounding civilian population. It is conceivable that northern labor in southern areas may be more susceptible than the native population, and southern labor, potentially carriers of malaria, moving northward constitutes a much more potent factor in disease incidence than the northern carrier. Official entomologists thus have a potential burden placed on their shoulders that must be reckoned as one of war's additional demands upon them.

4. Protection of crops and animals: Food for man and beast, fibers and animals and animal products are as important as munitions. Without adequate supplies for our armed forces, for civilian needs at home and for the armed forces of our allies and their women, children and non-combatants, the whole effort would bog down. To produce sufficient, without any consideration given to insect losses, is a stupendous task under prevailing loss of man power and shortages of machinery and materials. As an example of what is expected, consider the request for an increase in honey, wax and bees for pollination of seed crops. In the first World War, under the incentive of a free market, and with little interference from the draft, beekeepers doubled the yield of honey. Now, with an artificial price ceiling and, up to recently, no provision in the latest directives in regard to beekeepers as agricultural labor, the increase is still requested. Entomologists under these conditions must attempt to center the keeping of all bees in the hands of the most experienced and proficient, and constantly battle the magazine propaganda that makes beekeeping seem so simple and just the thing for every farmer, suburbanite or even city dweller, to do as a patriotic duty.

Other examples could be cited, but it is sufficient to point out that in general all crops are subject to large scale insect losses, that the farmer rarely knows that the losses are occurring until the damage is done, and that when he does act it is usually "too little and too late." Under present shortages of experienced extension workers to assist the farmer who is handicapped by shortages of labor, machinery and insecticide's the problem is acute. Entomologists have a vital part in food production.

5. Supervision of inexperienced workers: to date approximately 600 entomologists are serving in the armed forces, leaving the supervision of the entomological work to a greatly reduced force in every state. Research in federal and state agencies is likewise curtailed. It is of great importance that research continue unabated.

The emphasis should be on those problems that have a direct bearing on the war effort, without neglect of the fundamental studies in taxonomy, physiology and morphology. Obviously it is more important to work on the insect problems of food crops than on the insects of flowers or ornamentals. But even research must give way where necessary to the winning of the war.

The supervision of the protection of grain stored on account of the "Ever Normal Granary" is a case in point. Recently Farrar and Flint[1] of Illinois have published data on the control of insects in over 14,000 bins within the state, representing over 30,000,000 bushels of shelled corn. This work was done prior to our entry into the war. Similar problems exist in other states and need to be supervised now under our reduced man power situation. Insects left unchecked can easily destroy the major portion of our vast supply of corn and wheat stored on the farms and in terminal elevators. Who will supervise the tremendous job of protecting the "Ever Normal Granary?" The victory garden got off to a late start last year, but should be in full swing this year. Entomologists must make provision to supervise the control of garden insects. Supervision in all such cases requires trained and experienced personnel, a time element factor, and travel priorities.

This is a brief summary of the outstanding demands facing the entomological profession (with little documentation because it is presented to working entomologists). The supply of trained entomologists may become inadequate due to the needs of the Sanitary Corps of the Army and the Medical Corps of the Navy plus the number of entomologists in the military forces in various non-entomological activities, and therefore methods of meeting the demands must be worked out for each state. Under short rations of gas and tires, greater use must be made of correspondence, timely concise publications, the newspapers, the radio and the telephone.

As one method of meeting the man power shortage, it is possible to train individuals, not engaged in war activities, to make specific observations and report them in a specified manner to some central coordinating agency from which weekly and necessary emergency releases may be sent to the local and metropolitan press. To make such a service effective requires careful field training of intelligent individuals.

With such training, experience teaches us that effective help may be rendered by non-entomologically trained personnel. With the drafting of 18-year-olds, college training of entomologists is apparently largely out for the duration and in some institutions where most of the facilities are under contract to the Army, even the possibility of training women entomologists seems to be greatly reduced.

On those entomologists who are on a deferred basis falls an ever increasing burden. They will have to extend their hours and their efforts, devise new and better ways of meeting the demands for information and help, and come to a realization of the importance of their contribution to the war effort. It takes a good soldier to be a mere citizen these days. Protection of food, fibers, animals and man from insect depredations is so important that the deferred man power devoted to that end should be given all facilities to make possible the efficient conduct of the work.

What of the future? Since it is manifestly impossible to create entomologists over night, those schools in which it may be possible to continue the teaching of entomology should endeavor as in the past to emphasize the fundamental concepts of entomology bolstered by the basic sciences and humanities so that when this war is over, there will be available at least a few replacements to pass the baton. It may even be necessary to concentrate the teaching of entomology in a few institutions. New introductions of insects are almost certain to develop as a result of the annihilation of space by airplane travel. New crops developed as a result of shortages brought about by the enemy occupation of the lands where they have been customarily obtained will undoubtedly suffer from new enemies or the transfer of the enemies of other crops to the new crops. The demand for entomological work will be an increasing task for those who remain. No effort is too great, no sacrifice too far-reaching, if they contribute to the winning of the war. Just what part each entomologist must play is a matter for individual decision; whether

[1] Control of Insects in Fourteen Thousand Corn Bins. J.E.E., Vol. 35, No. 5, pp. 615–19.

to stay in a civilian status in order to carry part of the burden behind the lines or to offer one's technical skill and training to the armed forces may be a difficult decision for some. Entomologists have been, and are, making that decision with the single thought "what can I do to serve my country best."—2-5-43.

ERNEST N. CORY,
College Park, Maryland

OBITUARIES

Arthur Hinton Rosenfeld, 1866-1942

Battle casualties are only part of the loss suffered by science in total war. Of the loss to entomology and sugar-cane technology, the sudden death by heart attack of Arthur H. Rosenfeld in Washington, D. C., on October 6th, is a recent example. With his family ordered out of Egypt, where he was employed by the Ministry of Agriculture, on twenty-four hours notice last summer when the threat of invasion seemed so imminent, the airplane trip back to the States was apparently uneventful, but as the fatal sequel was to indicate, not without hidden strain. Shortly after arrival he wrote: "I flattered myself that we had all kept very calm and collected before and during our trip, but now I wonder!"

Graduated from the Virginia Polytechnic Institute, young Rosenfeld's first employment was as assistant to the State Crop Pest Commissioner of Virginia. Soon after he went to Illinois, where at that time it was confidently expected that the invasion of the San José scale was to be stopped, and the pest eventually eradicated in the United States. Later employed by the Louisiana State Crop Pest Commission, working on the Argentine ant, particularly in its relations with sugar-cane insects, he was the logical candidate for Entomologist of the Tucuman Sugar-Cane Experiment Station in Argentina when it was organized in 1910.

At that time Tucuman was incredibly primitive and remote, for with no direct steamship connection between the United States and Argentina, it was reached only by going first to Europe. The Station had a minute technical personnel, and three years later when disaster threatened on the death of the Director, the office naturally devolved upon Rosenfeld. This marked the end of his active career in entomology, and the joint publication with T. C. Barber on the sugar-cane moth borer, appearing in 1914, shows that already his primary interest lay in the relations of the insect to its host crop and its cultivation. The experiences of the next few years as Director of the Station in working out superior methods of cane cultivation were so forcefully and persuasively presented by him to the growers that the obvious next step was as Superintendent of Agriculture for Ingenio Santa Ana. This was the largest Central in the Province of Tucuman, and here he could try out his recommendations on a field scale and prove their commercial value.

It was this Horatio Alger success story that was told to budding entomologists in Dr. W. D. Hunter's Division of Southern Field Crop Insects, not of "far away and long ago," but while admittedly far away, just as definitely of right now. But if distance lends enchantment, the next stages nearer home prove that each step in Argentina was only a logical development in Rosenfeld's career. In 1923 he came to Puerto Rico as Special Technologist for Cane at the Insular Experiment Station. It was at this time that the writer first knew him personally, and quite aside from his delightful personality, was amazed at his incredible energy, how much he found to do, and the number of publications he prepared, of which the "Monograph of Sugar-Cane Varieties" appearing in 1927 is the most extensive.

His survey of agricultural conditions in Peru, and of the possibilities for their improvement, led to the planning under government auspices of an Agricultural Experiment Station at La Molina near Lima. It was to be uniquely administered, however, directly by the agricultural interests concerned, organized as the "Agraria,' and was correspondingly responsive to their needs.

Newspapers called him the "sugar-cane tsar of Louisiana," but the official title was Consulting Technologist of the American Sugar Cane League (1927–1932), and the requirements demanded just those extensive technical and practical experiences that the years abroad had supplied. The later activities in Egypt and temporarily in South Africa were only a further extension of such specialized knowledge, while the newer problem of colonization in Santo Domingo that he was just about to take up required similar qualifications. No ivory tower theorist can deal with the practical problems of most economically growing sugar-cane, even tho specialized technical knowledge and experience are equally essential. To meet and deal effectively with all kinds of people of many different nationalities and ranks of society needs just that happy, sunny disposition that Rosenfeld possessed. Entomology supplied the initial impulse, and if most of these later developments seem far afield, his continued membership in the "American Association of Economic Entomologists" testifies to an abiding interest. His death is a great loss to applied entomology.

He is survived by a wife and a son, Arthur, Jr., now a Sophomore in Virginia Polytechnic Institute. —2-15-43.

GEORGE N. WOLCOTT

Dillard Wister Grimes, 1891-1943

The State Plant Board of Mississippi lost one of its most faithful and conscientious workers in the death of Dillard Wister Grimes in the Veterans Hospital at Memphis, Tennessee, February 12, 1943. He was born at Ratliff, Mississippi April 8, 1891. He was graduated from Mississippi A. & M. College (now Mississippi State) in 1914 with major work in entomology. Soon after graduation he was employed by the Florida State Plant Board for over two years in citrus canker eradication and nursery inspection. He then went into the Army and saw service in France.

In 1919, Mr. Grimes was employed as Nursery Inspector and Field Entomologist by the State Plant Board of Mississippi and continued in this position for the next six years. In 1926, he resigned to become Entomologist for the Delta Branch Experiment Station at Stoneville, Mississippi, but about two years later he returned to the State Plant Board and took charge of its field station at Durant, which position he held until his death. He suffered a terrible blow in the untimely death of his wife in 1935.

Mr. Grimes was highly respected and liked by all who knew him and was known among his fellow workers and among the farmers he helped for his ability and his untiring devotion to the duties of his position. There was no such thing as an 8-hour day for him and there is little doubt that neglect of his health because of complete absorption in his work resulted in his death. His loss will be felt keenly by all his associates in the Plant Board, and in fact, by all who knew him, for wherever he worked he impressed people with his sincerity and desire to render service.

Mr. Grimes was a student and constantly endeavored to make himself more valuable to the Plant Board and the people he served. He received the Master of Science degree in entomology from Ohio State University in 1940 and had done considerable work toward the doctorate. He was a member of the American Association of Economic Entomologists for many years prior to his death. He is survived by a daughter, Mrs. A. L. Lane, Jr., and a son, Charles.

CLAY LYLE

REVIEWS

Outlines of Entomology. By A. D. Imms, N. Y. E. P. Dutton. 184 p. 96 figs. 1942. Price $3.75.

This condensed, little book might well have been entitled the fundamentals of entomology for such it is.

The author, who is a distinguished teacher of Entomology at Cambridge University, Cambridge, England, has presented his material in four chapters following a short introduction. These chapters are Anatomy and physiology, Embryology, growth and metamorphosis, Nomenclature and classification and Relationships of insects.

In his introduction, the author presents the characteristics of insects which have enabled them to attain "their dominant position in the animal kingdom." This is an intriguing way to introduce the subject of entomology to students. While he describes the advantages of the exoskeleton of insects, the author does not anywhere recount the disadvantages or limitations of the exoskeleton.

It is sometimes said that an understanding of the technical nomenclature of a subject provides a good understanding of that subject. The author has presented the subject matter in Chapters two and three somewhat in the form of an enlarged glossary. The technical terms are conveniently printed in italics. The illustrations, while not numerous, are clear, well selected and clarify the text admirably. Entomologists will observe that the author uses the terms "epicuticule" and "exocuticle" for the more familiar dermis and epidermis or endocuticula and exocuticula. His discussion of the nervous system and the sense organs is superior to that found in any basic, general text in the U. S. Teachers may well accept this author's evaluation of this phase of the subject and devote more time to it in their teaching. The concise description of embryological development is a model of fundamentals plainly presented.

The author might be considered in his discussion of metamorphosis not quite up to date however by some entomologists. He does not differentiate by classification between the direct or gradual metamorphosis of the terrestrial and parasitic orders of hemimetabolous insects and the indirect or incomplete metamorphosis of the aquatic orders. He however mentions the special adaptations for aquatic life.

Certain fundamentals of nomenclature and the orders are described in chapter four. The orders are well characterized, but families, genera and species are mentioned only incidentally as they are used in the discussion. There is no attempt to present the family classification of the orders which would be utterly impossible in such a brief presentation of the subject. The author has succeeded remarkably well in attaining his objectives in this chapter.

The discussion of mouthparts is given under the orders of which they are characteristic. Existing tests generally have a chapter on mouthparts which includes all of the types. Most teachers probably prefer this method of presentation but discussing the types under the orders has certain advantages.

When will entomologists come to a final agreement on ordinal names? In this text, there are several unfamiliar ones such as the orders Diplura and Aphaniptera. Others not yet fully accepted are Embioptera, Ephemeroptera, Psocoptera and Hemiptera including the Homoptera.

The discussion of the relations of insects to other arthropods is placed at the end of the book. This is as it should be. Students can not appreciate the meaning of a phylogenetic tree nor the significance of small, morphological characteristics in the different classes nearly so well at the beginning of a course as at the end of it. Existing texts tend to present this material too early.

As a whole, the author has produced a teachable, useful, brief presentation of the fundamentals of entomology. This text is well suited to a first course for upperclassmen preferably with some courses in

zoology preceding it. This is an ideal text for a first course in entomology in a zoology department. It is also an excellent text for a second course of the advanced general type where the introductory course is primarily economic or applied. It will be especially useful to teachers in entomology and zoology as a refresher text of technical information for classroom preparation. The text by its brevity and condensation therefore supplies a genuine, unfilled need. Dr. Imms is to be congratulated on this excellent contribution.

ROGER C. SMITH

Manhattan, Kansas
February 17, 1943

Handbook of Economic Entomology for South India. By T. V. Ramakrishna Ayyar, pp. xviii & 528, pl. 1, fig. 413. Madras, Government Press, 1940, price Rs. 4-12-0.

Subtracting the pages of index and bibliography, and of appendices of classification and insecticides, and comparing the remaining number of pages with the number of figures only begins to tell the story of how lavishly this book is illustrated, for many pages, paged as text, but actually plates, are given over entirely to the illustration.

"Miss Ormerod, the pioneer agricultural Entomologist of England, wrote as early as 1885 thus: 'I may most truly say that, if the crop or timber or fruit growers of India were furnished with plain and comprehensive accounts of the history and habits of the common insect pests, accompanied by woodcut figures, so as to convey the appearance of pests without wearisome description of details, all this would be a national benefit, repaying the outlay a hundred times.' With this important statement in view attempts have been made to illustrate the text with as many diagrams and figures as possible."

Thus we find an impressive number of the economic insects of south India illustrated, but nevertheless, the book is no mere picture book, but an all too succinct account of all the economic insects arranged by crops or interests of man affected. Some of these crops are familiar enough, but soon we are immersed in the insects of paddy, which turns out to be rice, or pulses, redgram, gingelly, groundnut, safflower, gogu, sannhemp, agave, brinjal, lady's finger, cluster bean, drum stick, amaranthus, garlic, chillies, colocasia, elephant foot yam, koorkan, curly leaf plant, pomegranate, woodapple, jujub, sapota, custard apple, jambu, tamarind, cashew, nelli, bilwa, palmyra, areca, indigo, nuna, tumeric, ginger, cummins, coriander, aniseed, pepper vine, betel vine, cardamon, ganja, cinnamon, cocoa (which turns out to be cacao and not coca), chinchona, champaka, jatropha, agathi, daincha, murukkam, nim, babul, pungam, portia, rain tree, peltophorum, poinciana, asoka and teak. "The teak defoliator (*Hyblæa puera* C.)" we read, is "found in all teak areas." And yet in Puerto Rico, where teak is a common introduced tree, this insect attacks one other introduced tree and two that are presumably native, but has never been noted on teak. There are chapters on honey bees, on silkworms, and on lac, and finally an account of how termites are collected for human food, to be "eaten raw mixed with parched ('popped') paddy. Only the lower castes eat this food." This merely skims the surface of all the interesting items that one will find mentioned, and often so briefly that only experience with the same or a similar insect, on the same or another host, enables one to appreciate how much has been compressed by the author into what is apparently an epitome of his lifetime of entomological teaching and research.—2-15-43.

GEORGE N. WOLCOTT

NOTES

SEVENTEENTH ANNUAL WESTERN COOPERATIVE SPRAY CONFERENCE

The Seventeenth Annual Conference of the Western Cooperative Spray Project was held at Yakima, Washington on February 9 and 10. This is an official conference, including entomologists, chemists, horticulturists, and plant pathologists engaged in research work on orchard spraying problems in the West.

Informal discussions were held on dormant sprays, fungicides, and on sprays for the pear thrips, red spider, aphids, pear psylla and the codling moth. The customary suggestions for the use of orchard sprays in the West were revised, as was a program of research work. The use of sprays on tree trunks to destroy the overwintering worms of the codling moth was of particular interest.

A luncheon on the second day was also attended by representatives of insecticide manufacturers and distributors, field men of growers' organizations, and horticultural inspectors. Afterwards, a joint meeting was held, presided over by A. J. Flebut, of the California Spray-Chemical Corporation. There was an attendance of 84 at this joint meeting, at which discussion centered around the availability of insecticides and fungicides during the emergency.

The following members of the Spray Project were in attendance:

California
G. F. McLeod

Idaho
E. C. Blodgett

Washington
L. K. Jones
W. A. Luce
W. J. O'Neill
E. L. Overholser
F. L. Overley
L. G. Smith
R. L. Webster

Oregon
Leroy Childs
O. T. McWhorter

U. S. Department of Agriculture
C. C. Alexander
F. W. Carlson
C. C. Cassil
F. P. Dean
William Holland
T. L. Kirkpatrick
E. J. Newcomer
M. A. Yothers[1]

E. J. Newcomer, of Yakima, Washington, was chairman of the conference, and F. L. Overley, of Wenatchee, Washington, was the secretary.—2-24-43

Correction:—The name of Mr. Harry B. Weiss was inadvertently omitted from the list of members of the Executive Committee as printed in the February issue of the JOURNAL.

War on the Locust[1]

Preparations for a spring offensive against the danger of a new attack by an old enemy behind the Middle Eastern and Mediterranean fronts are being actively pressed in London, and at strategic points between the Niger and the Indus. That enemy is the locust. Its armies can convert prosperous cornlands into temporary deserts more rapidly than the most destructive hosts of the Axis. Failure on these threatened fronts might have serious repercussions on allied strategy.

To save shipping, the armies in the Middle East should be able to draw on local surpluses of food and fodder without burdening the people of those regions. But if the local supplies are destroyed, large numbers of ships would have to be diverted to provide the necessary foodstuffs.

The locust has three highly destructive species: the red locust of Africa, which does not extend its incursions far north of the Equator; the migratory locust, and the desert locust.

Organizations for dealing with the first two pests were set up in 1939 by the British and Belgian Governments in Northern Rhodesia, and by the French on the Middle Niger. The desert locust was to have been dealt with by a special organization operating in the Red Sea region. But the outbreak of war stopped that. As a result, the desert locust opened a new attack in 1940 and is now threatening food and fodder supplies throughout the Middle East and East Africa. So far the situation is not very serious. But the invasion probably will reach its peak this year or next. Consequently preparations for a large-scale campaign have been completed.

This campaign will differ radically from those waged before. The earlier ones were essentially defensive and marked by two features—the hope of every Middle Eastern country that the locusts would single out a neighboring country for their attack, and the organization of control only within and along each country's frontiers.

Locusts, of course, are no respecters of international boundaries. The whole region from India to East Africa is open to invasion by migration flights, and developments at one extremity have their consequences at the other. Locusts are mobile creatures. In 1869 they reached southern England at a time when the nearest invasion center was the West African coast. The Red Sea and the Persian Gulf present no obstacles to their flights. And they can migrate in numbers that are astronomical. In Cyprus in 1881, 1,300 tons of locusts' eggs were destroyed. A swarm which crossed the Red Sea in 1889 was estimated to have occupied about 2,000 square miles of sky.

Faced by this mobile enemy, the British and cooperating governments laid their plans for a counter-offensive against his movements. Now the Anti-Locust Center in London can forecast the main directions of future migrations, season by season.

This spring the chief strategic areas will be southern Persia and Arabia. The swarms now present in southern Persia are a potential danger not only to Persia, but also the surrounding countries. The campaign there has been entrusted to British, Indian and Persian experts. They have been joined by Russian entomologists. All resources have been pooled, under the supervision of an international committee at Teheran.

In Arabia motorized parties of British, Egyptian and Indian experts are already at work. For the first time in history the locust is being attacked in a country where his devastations were as fatalistically accepted as sandstorms and droughts, and where he was allowed to breed unmolested. On the African side, where migrations to and from Arabia are frequent, an anti-locust mission is already established in Ethiopia, and extensive preparations against invasion have been completed in other East African territories. These are also designed to meet the red locust, in case it threatens food production in the African colonies.

The winter is relatively quiet, so far as locust emigration is concerned. It has been utilized for preparation for the allied attack. Large dumps of poison and bran for baits—the simplest and most practical method of dealing with these invaders—have been deposited at important points. Other measures for dealing with swarms have been taken.

The system of collecting reports on locust movements established by the Anti-Locust Center has been perfected and extended into new areas so that no country can now be overrun by sudden hosts of locusts without warning.

The general organization of the campaign is in the hands of the Interdepartmental Committee on Locust Control at the Colonial Office. The planning of the operations is entrusted to the Anti-Locust Research Center under two distinguished entomologists—Sir Guy Marshall and Dr. B. P. Uvarov, the leading authority on the locusts and their allies. British experts in the field form a Middle East anti-locust unit and are attached to the Middle East Supply Center. The armies and administrations are all helping them by providing transport, supplies and all other necessities to this striking force.

The campaign will be conducted in such difficult, remote and inhospitable areas that it would be rash to predict its immediate and complete success. But the preparations which have been made are well ahead of the existing developments, and they have been particularly designed to attack the locusts in the wingless ("hopper") stage, when they are most vulnerable and when the destruction of their concentrations can be carried out most effectively.

The establishment of an intelligence service which will report all locust movements, the posting of skilled observers at danger points, and the collaboration of existing local organizations in a common operational plan should prevent surprises. The coordination of government departments and of the armed services is assured by the interdepartmental Committee on Locust Control to take rapid decisions and translate them immediately into action.

The British Government is financing these operations. The necessary expenditure may be regarded as a premium on an insurance policy against a serious, if indirect, threat to the allied fronts from the Atlantic to the Indus.

[1] Reprinted by permission from the *London Times* through the courtesy of Miss Frances Cadzow, British Information Services.

SECOND ANNUAL MEETING OF PACIFIC NORTHWEST TRUCK CROP INSECT CONTROL CONFERENCE

The second annual meeting of the Northwest Truck Crop Insect Control Conference was held in the Imperial Hotel in Portland, Oregon, on February 2 and 3, 1943. Entomologists from the Northwest States of Oregon, Washington, Idaho, Montana, and Utah were in attendance. The plan of meeting initiated during the highly successful conference held in Walla Walla, Washington, in 1941 was followed. Three sessions were held at which only state, federal, and provincial entomologists working with truck crop insects participated.

Informal discussions were held on the following subjects:

Vegetable Crops, Insects Affecting.—L. G. SMITH, *Leader.*
- Peas—Pea Weevil, Pea Aphis, Pea Moth, Sitona Weevil
- Tomatoes—Tomato Fruit Worm, Tomato Horn Worm, Thrips
- Corn—Corn Ear Worm
- Beans—*Diabrotica*
- Asparagus—Beetle and Miner

Vegetable Crops, Insects Affecting.—W. E. SHULL, *Leader.*
- Potatoes—Flea Beetles, Payllids
- Onions—Thrips, Maggot
- Celery—Rust Fly
- Carrots—
- Cucurbits—Squash Bug
- Crucifers—Seed Weevils
  Root Maggots
  Flea Beetles
- Beets—Leafhopperligus

General Pests, Small Fruits, Ornamentals, Insects Affecting—H. E. MORRISON, *Leader.*
- General—Symphilids
  Nematodes
  Wireworms
  Slugs
- Bulbs—Bulb fly
- Stored products
- Hops—Red Spider, Aphids

The fourth and final session was attended by canners, growers, horticultural inspectors, and representatives of the insecticide industry. The following subjects were presented informally by representatives of the conference after which each subject was discussed by guests and members.

Shifting Research to War Effort—W. E. SHULL
Insecticide Situation—E. P. BREAKEY
War Vegetable Crop Protection—H. B. MILLS
Dispensing Insecticides—L. G. SMITH
Discussion Leader—T. A. BRINDLEY

Following the close of the conference a number of entomologists visited Corvallis, Oregon to review equipment, techniques, and facilities of the Department of Entomology of Oregon State College.

All presentations at the conference were informal. Presentations from tables or charts and the reading of formal papers were barred. Members gained much by this informal type of presentation. Many detailed problems were brought to the attention of the group and new suggestions for control on some pests were presented which would not have found their way into more formal papers.

The following members attended the meeting:

Baker, Wm. W.	Puyallup, Washington
Breakey, E. P.	Puyallup, Washington
Brindley, Tom A.	Moscow, Idaho
Chamberlin, J. C.	Forest Grove, Oregon
Courtney, W. D.	Sumner, Washington
Crowley, D. J.	Long Beach, Washington
Davis, John	Corvallis, Oregon
Doucette, C. F.	Sumner, Washington
Douglass, J. R.	Twin Falls, Washington
Eichmann, R. D.	Pullman, Washington
Gray, K. W.	Corvallis, Oregon
Hess, G. M., Jr.	Portland, Oregon
Johnson, E. C.	Pullman, Washington
Landis, B. J.	Union Gap, Washington
Lane, M. C.	Walla Walla, Washington
Mills, H. B.	Bozeman, Montana
Morrison, H. E.	Corvallis, Oregon
Mote, D. C.	Corvallis, Oregon
Peay, W. E.	Logan, Utah
Ritchie, C. L.	Portland, Oregon
Robinson, R. H.	Corvallis, Oregon
Schuh, Joe	Corvallis, Oregon
Shirck, F. H.	Twin Falls, Idaho
Shull, W. E.	Moscow, Idaho
Smith, L. G.	Pullman, Washington
Thompson, B. L.	Corvallis, Oregon

The executive committee in charge of the arrangements for the 1943 meeting were R. D. Eichmann, State College of Washington, Pullman, Washington, Chairman; D. C. Mote, Oregon State College, Corvallis, Oregon, Co-chairman; and J. R. Douglass, U. S. Department of Agriculture, Twin Falls, Idaho, Secretary. The staff of the Entomology Department of Oregon State College acted as hosts for the meeting.

The following executive committee was elected for the coming years: W. E. Shull, University of Idaho, Chairman; M. C. Lane, U. S. Department of Agriculture, Walla Walla, Washington, Co-chairman; and Tom A. Brindley, U. S. Department of Agriculture, Moscow, Idaho, Secretary.

TOM A. BRINDLEY, *Secretary*

DON E. EYLES

Don E. Eyles is serving as Associate Biologist with the United States Public Health Service with headquarters at Memphis, Tennessee. His address is 847 Union Avenue, Memphis.

CAPT. ROGER L. PIERPONT

Roger L. Pierpont, formerly of the Delaware Experiment Station, is now a Captain in the Sanitary Corps. He is stationed in West Africa with one of the Malaria Survey Units.

PROCEEDINGS OF THE FOURTEENTH ANNUAL MEETING

EASTERN BRANCH, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Hotel New Yorker, New York, N. Y. November 19 and 20, 1942

Chairman W. S. Hough called the meeting to order and presided over the regular sessions. The program included 31 papers. A round-table discussion on alternate insecticides took place on the afternoon of November 20. This part of the program was arranged by Neely Turner and conducted by Philip Garman. Various phases of the present insecticide situation, involving War Production Board orders, the work of the Bureau of Entomology and Plant Quarantine in connection with needs, reduced dosages, supplies, shortages, specific problems in control, dangers in the use of some alternates, etc., were discussed by Philip Garman, S. A. Rohwer, J. L. Horsfall, Harry F. Dietz, Harry G. Walker, Bailey B. Pepper, F. B. Maughan and others.

Harry B Weiss, President of the national Association mentioned some of the plans for the approaching national meeting especially those connected with the war effort of the country. He also spoke of the important work being done by the three war committees of the Association and of the numerous members of the Association who are serving the country in the armed services.

S. A. Rohwer brought greetings and best wishes from P. N. Annand, Chief of the Bureau of Entomology and Plant Quarantine who was unable to attend.

The Chairman, W. S. Hough, appointed the following committees:

Nominations: HARRY F. DIETZ, *Chairman*, J. O. PEPPER, B. B. PEPPER.

Auditing: S. W. BROMLEY, *Chairman*, H. M. STEINER.

Resolutions: J. L. HORSFALL, *Chairman*, R. B. FRIEND, HUGH GLASGOW.

W. H. Whitcomb, Cornell University Agricultural Experiment Station, Ithaca, N. Y. was elected to affiliated membership.

The Secretary-Treasurer in advance of his financial report mentioned the highly successful meetings in Baltimore in 1941, and the present good, financial condition of the Branch. For the record he stated that the fourth or 1941 annual award was made to L. A. Carruth of Geneva, N. Y., for his paper entitled "An Investigation of the Mineral Oil Treatment for Corn Earworm Control," which was published in the April 1942 issue of the "Journal."

The Eastern Branch cooperated with the Biometrics Section of the American Statistical Association by holding two sessions on statistical problems in entomology at the Biltmore Hotel, New York City, on December 29, 1941. F. Z. Hartzell acted as chairman of a session on the design and analysis of experiments on insects control, and Roger B. Friend, as chairman of a clinic on entomological problems.

The following report was submitted by F. L. Campbell and read by the Secretary-Treasurer. After considerable discussion by various members, the Branch voted that it be received with favorable consideration.

REPORT OF SPECIAL COMMITTEE ON ENTOMA

In the spring of 1942 this committee was appointed by President Harry B. Weiss to study the conflicting views of the Eastern Branch and the Pacific Slope Branch on future publication of Entoma and to make recommendations for consideration by the Eastern Branch and the parent Association at their respective annual meetings in 1942.

Briefly, the Pacific Slope Branch contends that Western listings in Entoma are incomplete and therefore it is not satisfactory for use on the West Coast. This Branch feels that the listings can best be completed by publishing *Entoma* under the auspices of the parent Association, with an editorial committee representing all parts of the country and that it would be desirable to strengthen the parent Association in this way.

The Eastern Branch points out that *Entoma* is a successful and profitable enterprise initiated by the Branch as a source of revenue to meet expenses peculiar to the Branch, that the Branch cannot operate in its accustomed manner without *Entoma*, and that the objection of the Pacific Slope Branch to inadequate listings can be easily overcome by cooperation between the two Branches.

The Pacific Slope Branch is not eager to spend time and effort in making money for the Eastern Branch, but would do so for the Parent Association. Without opportunity to work for Entoma through the parent Association, the Pacific Slope Branch would seriously consider issuing its own Directory for the West Coast.

In order to study the foregoing problem, the Committee was provided with detailed factual briefs furnished by the secretaries of the two Branches and with a general discussion of the problem written by the Chairman. The following recommendations are based on thoughtful consideration of this material.

(1) Publication of *Entoma* by the Eastern Branch should be continued during the war, because—

- (a) Change in personnel of the Editorial Committee might upset plans now being made for the next edition of *Entoma*.
- (b) The Executive Committee, busy with war duties, probably cannot now take time to work out a plan for properly compensating the Eastern Branch for loss of *Entoma*.
- (c) The insecticide industry of the West Coast is now organized and cooperating as never before and should be able to provide listings and advertising for *Entoma* through the Agricultural Insecticide and Fungicide Association and the Pacific Insecticide Institute, with little effort on the part of West Coast entomologists.

(d) Time is needed to acquaint all entomologists with the problem.

(2) *Entoma* should be transferred to the parent Association after the end of the war, provided—

(a) The Eastern Branch recognizes the desirability of placing national entomological undertakings in the hands of the parent Association, and will voluntarily offer *Entoma* to the parent Association.

(b) The Pacific Slope Branch does not start a Western Directory.

(c) The Executive Committee of the A.A.E.E. does not forget its present and continuing responsibility to work out an acceptable plan, not only for compensating the Eastern Branch for loss of *Entoma*, but for placing all Branches on an equitable basis with respect to publication in the JOURNAL OF ECONOMIC ENTOMOLOGY and other financial relations with the parent Association.

(3) All Branches should pull together to build the strongest possible national Association for the benefit of all entomologists and their service to the Nation, patiently striving to overcome existing differences.

A. M. BOYCE
R. E. CAMPBELL
C. C. HAMILTON
J. S. HOUSER
CLAY LYLE
NEELY TURNER
F. L. CAMPBELL, *Chairman*

The financial Report of the Secretary-Treasurer, the Report of the Editorial Committee for *Entoma* and the reports of the other committees were all adopted by the Branch.

FINANCIAL REPORT OF SECRETARY TREASURER

Balance on hand, November 14, 1941	$2,924.31
Receipts	
Additional dues for 1942	$ 189.00
Dues for 1943 to November 9, 1942	72.00
Receipts from *Entoma*	160.00
Interest on Savings Account	11.17
Total Receipts	432.17
Total, Receipts plus Balance of November 1, 1941	3,356.48
Disbursements	
Lantern and operator 1942 meeting	$ 40.00
Payment to Secretary-Treasurer for 1941	200.00
Clerical Services	
Eastern Branch	25.75
Entoma	22.90
Postage, Eastern Branch	30.00
Printing	
Programs, 1941 meeting	26.50
Entoma	11.00
Proceedings 1941 and over-run of 1940	624.11
Stationery, Eastern Branch	6.50
Award of 1941 and related expense	98.58
Expenses, Secretary-Treasurer	4.60
Expenses, C. C. Hamilton to San Francisco, etc.	266.66
Bank charges on checking account	.16
Total Disbursements	1,356.76
Balance on hand, November 9, 1942	1,999.72
Distributed as follows:	
Savings Account No. 17424, Trenton Trust Co.	1,060.16
Checking Account, Trenton Trust Co.	939.56
	$1,999.72

HARRY B. WEISS
Secretary Treasurer.

Audited and found to be correct.
S. W. BROMLEY
H. M. STEINER

REPORT OF THE EDITORIAL COMMITTEE FOR *ENTOMA*

November 1, 1941 to November 1, 1942

The report of the Editorial Committee for *Entoma* this year will be brief in order to save paper and ink. The normal activities in connection with the sale of *Entoma* have occurred. Briefly, they consisted of 30 copies of *Entoma* furnished free to libraries or other persons entitled to receive them and of 120 copies sold, for total receipts of $118.75. The expenditures for stamps, telephone, bank commissions, stationery and clerical help have consisted of $26.06.

The Chairman of the Editorial Committee attended the National meeting of the American Association of Economic Entomologist held at San Francisco, California last December and entered into a discussion with a committee appointed by the Pacific Slope Branch concerning the possibility of *Entoma* being sponsored by the American Association of Economic Entomologists. As a result of this conference a committee was appointed by Mr. Harry B. Weiss, President of the American Association of Economic Entomologists, to formulate plans to be presented to the Eastern Branch for their consideration concerning this matter.

Under normal conditions work would have been started upon the preparation of the 5th edition of *Entoma*. This has been delayed awaiting report of the committee mentioned in the preceding paragraph and because of the unsettled condition created by the war. In September Mr. Lee Hitchner, Executive Secretary of the Agricultural Insecticide and Fungicide Association, sent out a circular letter to members of their association to ascertain their sentiment relative to a revision of *Entoma* and to find out whether they would support a new edition. Ten letters were received stating that they would support a new edition. These concerns were mostly full page advertisers. The sentiment generally seems to be favorable towards issuing a revised edition in 1943.

NEELY TURNER
J. L. HORSFALL
R. C. ROARK
H. B. WEISS
H. N. WORTHLEY
CLYDE C. HAMILTON, *Chairman*

REPORT OF AUDITING COMMITTEE

We have audited the financial statement and books of Harry B. Weiss and find them to be correct.

H. M. STEINER
S. W. BROMLEY, *Chairman.*

November 20, 1942.

REPORT OF COMMITTEE ON RESOLUTIONS

WHEREAS, the beloved Dean of American entomologists, Dr. L. O. Howard, has been unable to attend these meetings, therefore

BE IT RESOLVED, that the Secretary convey to him our deepest respect and warmest greetings.

WHEREAS, a number of the members of the Eastern Branch are now serving with the armed forces of the nation, therefore

BE IT RESOLVED that the Secretary extend to these members the best wishes of the Eastern Branch, and

BE IT FURTHER RESOLVED that these members shall be continued on the roster during the present emergency without payment of dues.

WHEREAS a knowledge of the availability of insecticides is important to entomologists in planning insect control programs which are necessary for food production, therefore

BE IT RESOLVED that the Bureau of Entomology and Plant Quarantine be commended for the excellent service which it has performed in the preparation and circulation of the information in its War Letters to the entomologists responsible for planning and executing control programs.

WHEREAS it has been customary to publish *Entoma* each odd-numbered year and there has been some question as to the advisability of publishing the directory in 1943, and

WHEREAS a preliminary canvass of advertisers has indicated that sentiment favored publication, therefore

BE IT RESOLVED that the Eastern Branch hereby indicate its approval of publication in 1943.

WHEREAS, through the kindness of Mr. L. Hitchner, Secretary of the Agricultural Insecticide and Fungicide Association, the services of Mr. Don Stetson, in charge of Public Relations for the Association were made available to the Eastern Branch, and

WHEREAS Mr. Stetson has handled the publicity for our meetings in a most intelligent and effective manner, therefore

BE IT RESOLVED that the Eastern Branch extend to Mr. Hitchner and Mr. Stetson its thanks and appreciation for this service.

WHEREAS the management of the Hotel New Yorker has thoughtfully provided most excellent facilities for these meetings, therefore

BE IT RESOLVED that the Secretary extend to the management the sincere thanks of the Eastern Branch.

R. B. FRIEND
HUGH GLASGOW
J. L. HORSFALL, *Chairman.*

REPORT OF THE NOMINATING COMMITTEE

Your Committee on Nominations proposes the following persons to serve as officers of the Eastern Branch of the American Association of Economic Entomologists for the coming year:

For Chairman: M. P. JONES
For Vice Chairman: HUGH GLASGOW
J. O. PEPPER
B. B. PEPPER
H. F. DIETZ

The following guests and members registered during the meetings. The attendance and interest were unusually good during all sessions.

Adams, James F.
Anderson, Lauren D.
Arnold, R. B.
Bales, I. W.
Beard, R. L.
Beckwith, Charles S.
Beinhart, E. G.
Bellemare, E. R.
Bemis, W. G.
Bromley, Stanley W.
Buchholz, A. B.
Buettner, William O.
Burgess, A. F.
Cazier, Mont A.
Chapman, P. J.
Clark, C. A.
Collins, C. W.
Collins, Donald L.
Cowan, E. Karl
Deal, John
Dean, R. W.
Dewey, James E.
Dietz, Harry F.
Donohoe, H. C.
Driggers, B. F.
Eastman, P. M.
Evans, J. A.
Felt, E. P.
Filmer, Robert S.
Fracker, S. B.
Friend, Roger B.
Fournier, Father Ovila
Garman, Philip
Gemmell, Louis G.
Gertsch, W. J.
Ginsburg, J. M.
Girth, Harold B.
Glasgow, Hugh
Glasgow, Robert D.
Gould, Edwin
Granett, Philip
Guy, H. G.
Guyton, T. L.
Hamilton, Clyde C.
Hammer, O H.
Hansens, Elton J.
Hanson, Charles
Hartzell, Albert
Haynes, Harry L.
Heal, Ralph E.
Hodgkiss, H. E.
Horsfall, J. L.
Hough, W. S.
Huckett, H. C.
Jaynes, H. A.
Jennings, Cedric C.
Johnson, C. C.
Johnson, J. Peter
Jones, M. P.
Ken, T. U., Jr.
King, Herman L.
Knutson, Herbert
Langford, George S.
Leiby, R. W.
Marvin, Philip H.
Maughan, F. B.
Menusan, H. M., Jr.
Mills, Alfred S.
Moore, Warren
Moore, William
Muma, Martin H.
Nelson, Franklin C.
Payne, Nellie M.
Pears, L. M.
Pechuman, L. L.
Pepper, Bailey B.
Pepper, J O.
Poos, Fred W.
Pyenson, Louis
Reed, Lucius B.
Rex, E. G.
Rice, Paul L.
Richmond, Edward Avery
Riehl, Louis A.
Rolfs, A. R.
Rosenthal, Max
Sankowsky, N. A.
Sameth, J. Edwin
Shemen, Ralph
Sherman, R. W.
Shropshire, L. H.
Simone, A. C.
Smith, Claude R.
Soraci, F. A.
Steiner, Harold M.
Thompson, Robert R.
Townsend, James F.
Underhill, G. W.
Wallace, Robert T.
Walker, G. L.
Walker, Harry G.
Webber, Ray T.
Weed, Alfred
Weiss, Harry B.
Whall, Harry H.
Wheeler, Ellsworth H.
Whitcomb, William H.
Whitman, R. C.
Whitten, Russell R.
Wolfe, Leland
Wolfenbarger, D. O.
Wood, Henry J.
Woodbury, C. G.
Woodbury, E. N.
Zappe, M. P.

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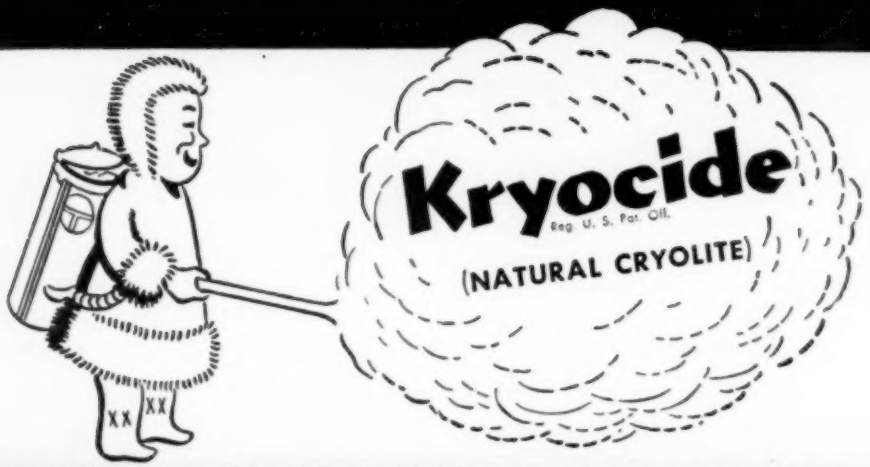

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PHOTOGRAPHS OF ENTOMOLOGISTS. The undersigned desires photos of entomologists to add to the collection now deposited in the Department at Ohio State University. This collection now numbers over 400 portraits, many of them having been included in the "Fragments of Entomological History." It is hoped that a supplement to that volume may include many more and any contributions will be gratefully welcomed. Herbert Osborn, Ohio State University, Columbus, Ohio.

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JOURNAL OF ECONOMIC ENTOMOLOGY

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